Fundamentals *of* Economic Geography

by

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Preface

THIS text is designed to furnish the subject matter for an introductory course in college geography. The authors believe that geography should be a basic science for all students, especially for those whose major interests are in the realm of the social studies, and that it should integrate fully with such studies. Therefore, the subject matter is presented with double emphasis, descriptive and explanatory. Although the description of the face of the earth is undeniably a true function of geography, mature study involves not only the presentation but also the interpretation of pertinent facts. For this reason the discussions devote much attention to causal influences; we believe that students should be encouraged to delve into the *why* of various conditions and activities. Inasmuch as this is primarily a treatise in economic geography, the consequential relationships have been considered largely from the standpoint of the activities whereby man makes his living. Emphasis is placed not upon industrial processes as such, but upon the causes of distribution of industrial activities and the significance of resulting production.

The choice of material for a text in the fundamentals of economic geography is of course subject to differences of opinion. We have tried to present such matter as will aid in developing a scientific and factual background for a better understanding of world production in the realms of agriculture, forestry, mining, and manufacturing. Exchange of commodities results from diverse, specialized regional production, and hence is not considered to be a field of major emphasis in an introductory study.

This book includes material designed to cover a full course for one-half year, or for a year's work on a three hour per week basis. The references at the end of each chapter have been selected from sources quite generally available. The extensive bibliography at the close of the book is a survey of source material used in its preparation, and furnishes references for

such intensive specialized studies as may be desired for advanced students. Where library facilities are available and the time devoted to the course permits, supplementary readings from the sources given are desirable. Where such facilities are not available in any large degree, the mastery of the material as given here will, we believe, justify the credit earned and validate the title of the book.

In the preparation of this volume we have had the kindly coöperation of so many people that specific acknowledgment must necessarily be incomplete. Among those who have read the manuscript in whole or part, and for whose criticism we are especially grateful, are: Professor John E. Orchard, Dr. L. A. Wolfanger, and Mr. Herman Otte, all of Columbia University; Professor Julia M Shipman, of Mt. Holyoke College; Dr. C. F. Marbut, of the U. S. Bureau of Chemistry and Soils; Professors Earl E. Lackey and Esther S. Anderson, of the University of Nebraska.

Special acknowledgment is also expressed for the generous coöperation of the Bureau of Foreign and Domestic Commerce in furnishing data not given in their regular publications.

Nearly all the graphs and diagrams and many of the maps were prepared by Mr. Marlo E. Smith. Mr. Walter Kollmorgen assisted materially in the preparation of the chapter on the "Economic Significance of the Sea." In the preparation of the manuscript for publication, the critical editorial assistance rendered by Dr. Vera E. Rigdon is gratefully acknowledged.

The book is presented on its merits. Into its preparation has gone the experience of many years of teaching the subject, and we believe that the organization of the material is along rational lines We hope that this presentation may be found helpful for college students and other interested readers who are seeking a fuller understanding of the factors which are basic to production and prosperity. We believe that such understanding is the safest guarantee of intelligent citizenship, and through it the stability of the nation.

NELS A. BENGTSON
WILLEM VAN ROYEN

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[Maps and diagrams are in italics]

Fundamentals *of* Economic Geography

CHAPTER I

The Field and Function of Economic Geography

THE desire to live well is a worthy ideal. In order to realize this desire man must be an efficient worker; that is, he must attain high production in proportion to the time and effort he gives to his various lines of activity. The comforts and luxuries which are characteristic of the advanced industrial peoples of today have been made possible by the high production per capita of the workers. For example, in the United States a large percentage of the laborers have among their ordinary comforts steam heat, electric lights, gas for cooking, sanitary water supplies, automobiles, and radios. Much of the food served on their tables has been shipped hundreds of miles, and often many different lands have contributed to the preparation of a single meal. Thus, there have come into the lives of humble citizens luxuries undreamed of a century ago Washington, Hamilton, and Jefferson were among the wealthiest aristocrats of their time, but they lacked most of the conveniences which we consider essential for physical comfort. Their luxuries were indeed simple as judged by the ordinary standards of the present day.

The high standards of living which mark the progressive industrial countries are the rewards of production. Their attainment has been made possible by a complexity of factors; if these standards are to be further advanced, or even if they are merely to be maintained, progress must be based on a sound understanding of the fundamental conditions which underlie them. Much of what man does is a reflection of where he is; this is true also of his hopes and fears, of his desires and ambitions. Environment plays a large part in the development of

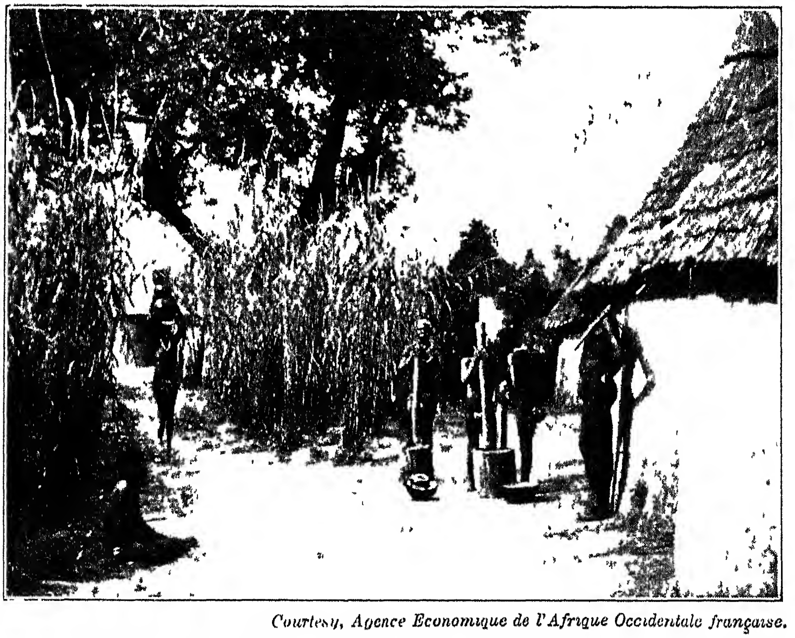
individuals and of groups It is in the study of the relation of environment to human activities and progress that Geography finds one of its major functions; Economic Geography uses as its keynote such environmental relationships as are fundamental to industrial and commercial activities.

Differences in environment lead to differences in activities. — Lest we forget, it is well for us to keep in mind that the high standards of living referred to are not universal over the earth. The changes in modes of living which have come to the people of the United States and parts of Europe during the past century are far-reaching and profound; not so, however, in the highlands of Bolivia, in the rain forests and jungles of Africa, nor even in parts of India or China Over much of the earth people are living about as they have lived for centuries past, doing the same tasks, thinking the same sorts of thoughts, spurred to the same kinds of action by the same hopes and fears which characterized their forebears. But even where this is the case there are striking differences in modes of living which are due to differences in environment, and these will not be greatly altered even though vigorous progress should displace the stagnant conditions of the past.

Illustrations of differences in environmental influence are so numerous and varied that no brief list of examples can wholly reflect the diversity of responses. The following may, however, help us to understand better just what we mean by environmental influence. The Eskimo considers himself highly favored if he succeeds in providing his family with an abundance of fish, blubber, birds' eggs, a sturdy dog team and sledge, and a well-constructed igloo for winter shelter. The jungle-dweller of Africa, on the other hand, has few worries as to food, raiment, or shelter; but his thoughts go toward avoiding his animal enemies and the depressing heat of his too-warm and humid climate. The former finds cold his greatest enemy to physical well-being; the latter must combat heat and humidity. Such differences in the natural environment not only affect the physical activities of man, but generally they also lead to fundamental differences in thoughts and ideals.

Courtesy, Milwaukee Public Museum

Fig. 1.—Life in the Arctic. Eskimos building igloos or snow houses for shelter while on the march.



Courtesy, Agence Economique de l'Afrique Occidentale française.

Fig. 2.—Life in the African Tropics. A negro village in the French Sudan.

The peoples of the different parts of Europe furnish us illustrations along the same line. The Norwegians, for example, are noted for their vigor, their thrift, their serious-minded views of social problems, as well as for their universally recognized skill and sturdiness in seamanship. Norway is a country of mountain ruggedness, thin and bowldery soil, and short growing seasons. The problem of making a living upon the land has never been easy of solution. The adjacent sea has been relatively friendlier than the land, and to it the Norwe-

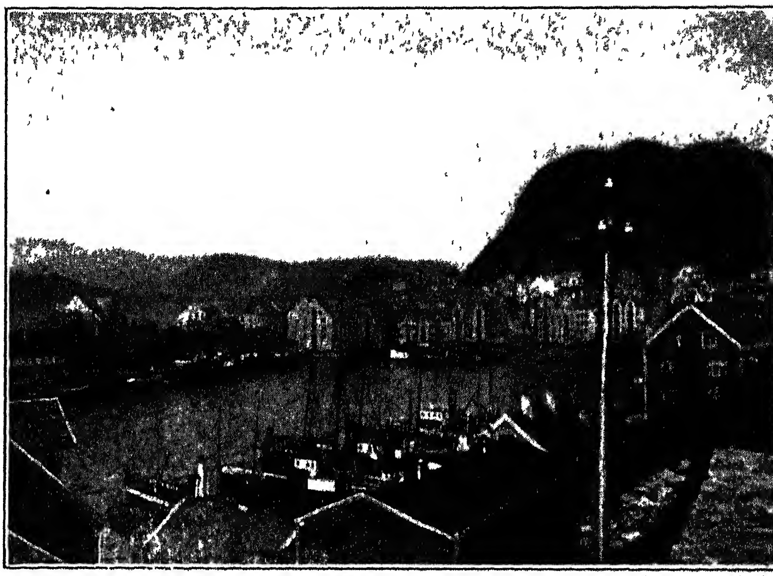


Photo by N. A. R.

Fig. 3. Aalesund, Norway. An important commercial center and the home of a large fishing fleet. The ruggedness of the coastline leaves but little room for business blocks and residences.

gians have ever turned in large numbers; but it too has demanded courage, strength, and alertness as prerequisites for success. Thus, through the ages, the stern environment of that northern land has impressed its demands upon the inhabitants, and only those who could meet them have survived. The Norwegians of today—strong, agile, alert, and serious—are in large measure the product of the environment which has fostered them.]

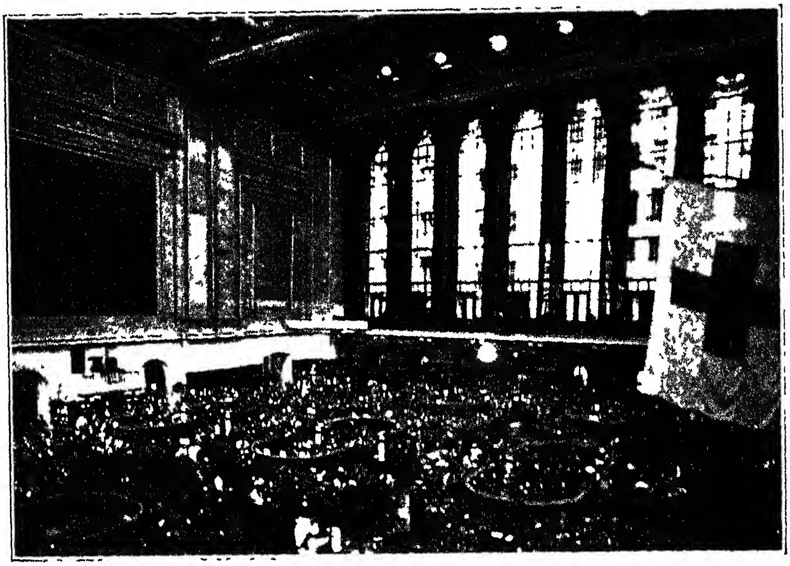
In southern Europe are a people, the Spaniards, whose mode of life and trends of thinking are quite different. That the contrasts in the characteristics of the Norwegians and the Spaniards may be due to a complexity of factors is granted, but even so the importance of environment as one of the foremost factors cannot be denied The merry, rollicking Spaniard is characteristic of the most favored part of the country—namely, the productive districts of Andalusia in southwestern Spain. The fertile and sunny valley of the Guadalquivir River has always yielded abundant produce, and has lacked the sternness with which Nature has faced the Norseman—why not then the merry, singing Spaniard? In that southern country of winter and spring rainfall and of summer sunshine, wheat can be grown successfully; and hence the Spaniard eats white bread This is in contrast to Norway where climate forbids wheat but makes rye culture possible; black bread is therefore the Norseman's staff of life. Each makes use of the products available, and in each case the geographic environment is the most effective influence.

But one need not go to distant lands in order to get examples of large-scale environmental influences. The men of Gloucester, Massachusetts, know and can relate stories of fish and the sea, but they know little of the daily lives of the wheat farmers of Kansas The business heads, clerks, even many of the day laborers who work in the financial districts of New York City speak glibly in terms of "margins," "soft markets," "accept profits," and "stop-loss orders"—terms which sound ominous and mysterious to the corn farmers of Iowa. But the Iowa farmers are keen judges of soil, of pigs and cows, and are as expert on farm practices as are their New York cousins on stock market activities The sugar planters of Louisiana live in a world quite unlike that of the sheepherders of Wyoming or that of the coal miners of Pennsylvania. In each case differences in environment lead to differences in activities and products as well as to differences in thoughts and ideals

¶ Environmental differences give rise to exchange of goods; that is, to commerce. One area produces a surplus of wool and

mutton, but has need for sugar—another has a surplus of sugar, but a deficiency of wool; one produces a surplus of wheat, but has need for cotton—another produces a surplus of cotton, but no wheat. Through exchange of surpluses the needs of all may be met, and all may profit by the exchange. In short, differences in environmental conditions are the basic causes of commerce.

Differences are, however, not limited to kinds of production; there are varying capacities as well. Some areas have great



Courtesy, Committee on Publicity of the New York Stock Exchange

Fig. 4.—Trading floor of the New York Stock Exchange.

productive capacity, others have but little. Some areas are highly exploited, others hardly touched. Under these diverse conditions it is to be expected that there are great differences in density of population as well. Some areas have their millions, whereas in others the dwellers are few.

Importance of uneven distribution of population.—As one studies the distribution of mankind over the earth, he finds sharp contrasts in density of population to be the rule rather than the exception. In Europe, Belgium has an average of

more than 650 people per square mile, whereas southeastern Russia has less than 10. Eastern China resembles a beehive in its population density, while western China is still a land of the great open spaces In Argentina most of the people live on the lowlands, whereas in Bolivia the lowlands are areas of sparseness. In Africa the lower Nile Valley presents a striking contrast in population with the nearby Sahara. In North America millions are crowded into the eastern metropolitan districts while the Great Plains have extensive areas where people dwell miles apart. Although these contrasts in population density are due to many causes, the most important are the results of differences in the natural environment Population density is not only a result of geographic factors, but is in itself important geographically, because economic life varies with the social elements of the environment as well as with the natural, such as climate and topography. Differences between city life and country life in the same area are expressive of the importance of the social rather than of the natural environment.

The significance of industrial progress.—While it is quite true that the natural landscape is continually undergoing change, the rate of change is so slow that to measure it in terms of years or even of centuries is difficult. Therefore, changes of this kind may practically be ignored when considering present human activities. Not so, however, with the cultural landscape. Cities rise and fall, states are born, grow, and decline, all within the memory of man. The revolutionary changes which have marked man's activities during the past decades have been made possible by the greater power with which he has done his work or has overcome obstacles and by his increased efficiency in utilizing favorable factors. For example, until man learned how to make deep wells he found it necessary to build his homes near streams or springs, or in valleys where water was easily obtainable With power available and mechanical ability developed, he could make wells for water on the uplands; agricultural settlements followed and became prosperous on lands formerly unused. By this change alone,

lands of vast extent became available for the production of food materials and for the sites of prosperous homes

Another illustration of the importance of rapid change may be cited from the realm of transportation. As long as horse-drawn carriages or wind-propelled ships were man's fastest modes of travel and freightage, the earth seemed large. Places a few hundred miles away were remote, and only non-perishable goods of high value could be exchanged with them. All transportation was slow, and land transportation was both slow and costly. World markets for the agricultural products of interior lands were out of the question, and only such products could be shipped by sea as would not easily spoil. Production of most of the needs of man was in close proximity to the places of consumption. Supplies of foods and raw materials were dependent almost wholly upon local sources With the development of rapid means of transportation and communication all this has been changed. Express trains, steamships, automobiles, airplanes, dirigibles, telephones, and radios have brought changes more revolutionary than most of us realize. The world has become smaller though its miles remain unchanged. From the viewpoints of trade, communication, and politics it is but a fraction of its size in the days of Washington and Jefferson. Then Europe was far away; now it is near. Then the voyage across the Atlantic involved weeks and sometimes months of discomfort; now it is made in five or six days of luxurious ease. The change has made Europe a market and a close neighbor instead of an area of little concern to us because of unbridged distance. The same can be said of South America, and even of Asia, Africa, and Australia.

These changes of technique have affected tremendously the whole social structure. The industrial nations, such as the United States, England, Germany, and France, have felt the influences most profoundly, but nearly all peoples of the earth have been affected in some degree; only a small percentage living in almost complete isolation, such as the Motilones of South America, the Congo dwellers of Africa, and some of the Arctic Eskimos, remain virtually untouched. Now the world is small.

Commodities and ideas are exchanged with almost incredible swiftness. The telegraph, the telephone, and the radio convey news to all parts of the world in fewer minutes than the number of months formerly necessary. Major events in any country are known in all other countries almost as soon as they occur. The progress in the exchange of goods has been almost as revolutionary as the progress made in communication The diner in New York eats head lettuce from the Imperial Valley, bananas from Honduras, and papaya from Puerto Rico at the same meal at which he drinks his cocoa from Africa or sips his tea from India If it be a hot day, he probably wears a suit made of a fiber from the tropics while his wife may wear a scarf made from the fur of the Arctic seal.

Before the advent of the industrial era, agriculture was almost the universal calling. Since no person could produce much above his own needs, there had to be many producers. Needs were simple, production was simple Each community was nearly self-sufficient, because it neither demanded nor knew how to use many outside products. Commerce was largely water-borne, and limited to such goods as could stand prolonged storage with little deterioration Overland haulage was limited to short distances, and to articles of small weight or bulk and of comparatively high value. Manufactures were simple, being largely of the handcraft, made-in-the-home type. But all this is changed. The greatest changes have, of course, taken place in the industrially progressive countries and the least in the industrially unprogressive.

Specialization of human activities.—Differentiation of activities is the outstanding characteristic of the present age. Instead of one man doing many things and being inefficient in all, one man does some one thing or manages some one line of activity and does that well. Specialization and tremendously increased energies available for power have increased the per capita production manifoldly. Individuals, communities, and states have ceased to hold to the idea of self-sufficiency, and each has become an efficient surplus producer of a few things while satisfying its other wants by exchange for the surplus

products of other regions. Want and famine are no longer necessary anywhere; such cases as occur are indicative of retarded development. On a world basis, a comfortable sufficiency of every commodity essential to human life seems assuredly possible for generations to come, although it may often be true that while one country or region has a large supply of a given necessity another may be in need. The fulfillment of that need will depend upon transportation facilities and upon the efficacy of our social and economic society. The high specialization of human activities, efficient per capita production, and low-cost means of commercial exchange and distribution are fundamental in raising the standards of living and in banishing the fear of famine from all lands.

Power and efficiency.—Production is of course vital to life. "In the sweat of thy brow shalt thou eat thy bread" expresses more than the dignity of labor it recognizes the basis upon which man must live. But to live well, to have comforts and luxuries, *efficient* production is necessary. Thus surpluses are produced, and these may be exchanged for the diversity of things which are implied in the expression "high standards of living." High production per man necessitates the use of power, without which per capita production remains low. Since power-utilization on a large scale has become a reality, the productive capacity per man has been increased more than a hundredfold; and the individual may have the fruits, products, and even the music and spoken thoughts from various parts of the world.

The industrial civilization of today faces a situation quite different from that which confronted the pioneers of America. Their problems were largely local; their interests were chiefly those which developed out of their immediate environment. They profited little from the products of distant lands and cared little about foreign problems. Now, however, all countries are close neighbors, haughty isolation is impossible, and the prosperity or adversity of one country becomes a matter of vital concern to many. The fundamental cause for this change lies in man's use of the power resources of sources

of energy that lay practically unused during the ages prior to the nineteenth century Through the use of coal, petroleum, natural gas, and falling water, every man, woman, and child in the United States has the equivalent of more than 60 human slaves working for him.[1] Because of these power resources, we have emancipated women and children from most of the toilsome labor which was formerly their common lot; and the working hours for industrial laborers have been reduced from 12-14 hours a day to 8 hours, and in many lines to only 6 hours a day. Notwithstanding the decrease in working hours, the daily wage has not suffered The worker receives more pay for his 6 to 8 hour day now than did his predecessor of Revolutionary times for his 14 hours of toil Under normal conditions the workers in the mills and factories have, on the whole, better working conditions than they ever had before, and they enjoy luxuries in food and recreation such as were deemed unattainable even by the wealthy classes before the industrial era.

The changes referred to above have been made possible through the utilization of the power resources of the world and the increased mechanization which they have induced. These resources are being exploited on a great scale, and the resulting activities are being directed by machines which in themselves are the results of power as well as responses to it Therefore, if one would gain a general understanding of the fundamentals which underlie our present industrial and commercial world, he must study the role which the power resources and the principal metals play. The properties, world distribution, and potential reserves of coal and petroleum are vital topics. The sources and distribution of metallic raw materials and the industrial significance of their manufactures are subjects which challenge every well-informed citizen

The land a fundamental resource.—Although utilization of power resources has been instrumental in bringing about revo-

[1] *Water Supply Paper, 579*, United States Geological Survey Washington, D. C

lutionary changes in industry and in modes of living, man must continue to draw his sustenance chiefly from the land While he uses the sea and the air as highways of commerce, the land is the scene of most of his activities, and it is his home. The industrial processes are applied directly to farming operations, to products of the land, or to communications over the land. Man uses the land for mine or timber or farm; there he builds his cities and erects his temples and shrines. In order to appreciate the significance of the land in our scheme of living, we need to learn something of its constituent parts, its surface features, and its distribution over the earth. The land is the stage on which the major part of the human drama is enacted, and in order to understand the play we need to know the setting of the scenes The land is the chief component of the natural landscape, and hence deserves careful study as an environmental factor.

Climate and commercial products. -Another of the objectives of geographic study is to gain an understanding of the natural conditions under which different commodities are produced. Climate ranks high among the factors which determine surplus and deficiency of various products, especially those of an agricultural nature. Successful management of many business enterprises requires a knowledge and an understanding of this factor. Such understanding aids greatly in purchasing materials where the surplus is largest and selling them where the need is greatest.

Differences in climate give rise to a multifold variety of occupations and products. The cotton of Georgia, the wheat of Kansas, the corn of Iowa, the coffee of Brazil, the rice of Burma, and the sheep of Australia are only a few examples of this diversity. Such differences quite naturally have led to exchange of products and to development of international trade. Where formerly only non-perishable goods of small bulk and high value could be exchanged, railway and steamship transportation and methods of canning and refrigeration have so greatly reduced costs and widened the possibilities of trade that the flow of commerce has been enormously augmented.

Thus modern invention and transportation have made the whole world kin, and we have a direct interest in what other people do, how they live, what they produce, and what they need. These are the keys to understanding as well as to trade Among the influences which affect man's mode of living, his pursuits and products, climate is universal and ranks second to none in its effectiveness. If students gain a general understanding of the conditions which prevail in the principal climatic regions of the world, they will see the basis for the diversity of activities, products, and needs which underlie trade.

The physical environment and geographical relationships.—Three outstanding aspects of the natural environment must be considered as the fundamentals of economic geography: (1) the land, which serves as man's home and the theater of most of his activities; (2) climate, because of its influence upon man's activities, products, and needs, and (3) the power resources, because of the revolutionary effects which the utilization of their energy has had upon man's productive capacity. To try to understand the relationships between human activities and the environment as exemplified by the land and its resources, by the climates of the world, and by the utilization of coal, petroleum, natural gas, and water power is surely a worth while objective in geographic study. Its achievement will lead the student to a sounder understanding of industrial problems and give him a broader grasp of the essentials of business success.

The problems of progress.—Inasmuch as the industrial civilization of today involves the utilization of mineral and power resources, and since the adaptation of industry to environment is essential to success, we must recognize that these are the keynotes to efficient production. Through them the world passes from scarcity to abundance, and from poverty to prosperity. Through them leisure may be made possible, and leisure gives opportunity for the development of culture in its finest sense. The increased effectiveness of human labor which marks man's part in industrial progress thus leads not only to higher standards of living and greater physical comforts,

but also to a larger degree of leisure among workers. Rightly used, this leisure may prove effective in promoting the development of a fine type of culture; wrongly used, leisure and luxury may become forces leading to the decay and destruction of civilization. The right use of resources depends in no small measure upon a sound understanding of the natural environment and its relationships to the cultural landscape. The goal of economic geography is to contribute effectively toward such understanding. It should not only lead the student to become a more efficient worker in the economic realm, but—and this is of even greater importance—it should enable him to meet more intelligently the problems of citizenship.

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CHAPTER II

Distribution of Population

THE uneven distribution of people over the lands is a geographic fact of great social and economic significance. In some places people live under such congested conditions that we are inclined to wonder how they can be comfortable, while in others they are so widely scattered that the isolation would appear oppressive. In certain areas even the rural districts contain hundreds of people per square mile, whereas other areas are virtually uninhabited. The density of population varies from that of the teeming millions on the lowlands of eastern China or in the industrial centers of northwest Europe to that of the sparsely peopled expanses of northern Canada or of the vast lowlands of the Amazon. Summarily stated, the outstanding fact of world distribution of population is its sharply contrasting densities in various regions. Recognition of this contrast quite logically raises the question: "What are the causes which give rise to this uneven distribution of people, and what are the social and economic consequences which challenge our attention?"

Causes and consequences of various densities of population.—Varying densities of population are often due to an interplay of causes, many of which are geographic. In some cases the dominant factors are simple and easily understood, as for instance the cold of Greenland or the aridity of Arabia—such harsh environmental conditions can lead only to sparseness. In other cases the factors are complex and difficult to analyze, as in the industrial centers of northwest Europe and of eastern United States; the densities characteristic of these areas are the results of several closely related factors. But while contrasting degrees of density are due to various causes, it is equally true that they give rise to various consequences,

many of which are of geographic importance. The facts of population distribution and their causes and consequences must all be considered together if the geographic study is to be complete.

In order to appreciate some of the direct consequences of the uneven distribution of people, it is well to apply the situation personally. Under what conditions do you as an individual live: in a crowded section of a city; in a small town or country village; or out in the country, typified by the well-known expression "the great open spaces"? Are you a dweller in an apartment where you have neighbors on three sides of you, neighbors above and neighbors below? Or do you live in the suburbs of a city where there is a cottage for each family and each cottage has its plot of ground for yard and garden? Perhaps you dwell on a ranch where your nearest neighbor may be a mile or even many miles distant. The differences suggested by these questions involve consequences that affect the activities, the sociability, and even the views of life of individuals. The ranchman can hardly be expected to understand fully the economic problems or the social outlook of the man who lives in the congested section of a city. Nor can the city dweller be expected to understand fully the physical conditions, the economic problems, and the social aspects of life which confront the ranchman on the plains.

Advantages and disadvantages inherent in areas of dense and sparse population.—People who live close together develop a consciousness of the group rather than of the individual. Dense populations tend to promote acquaintance with the crowd. Men who grow up under such conditions, if they have more than ordinary initiative, are quite likely to become leaders of groups and parties. Furthermore, dense populations are likely to have the aggregate wealth which promotes educational and social facilities, whereas sparse populations are usually not able to provide such facilities; and even where they are provided, the handicap of distance prevents their full utilization. The development of individuals into group leaders and the fostering of the spirit of group activity, a form of teamwork,

are properly classed as among the most important results of the influences of dense population. That much of the political, social, and religious leadership of today hails from the city is a natural consequence of the training which comes from living in close association with other people.

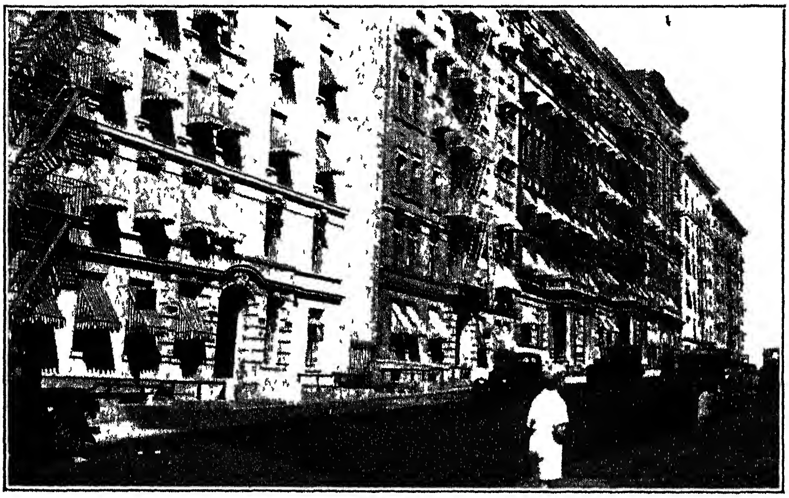


Photo by N. A. B.

Fig. 5.—Apartment houses in Morningside Heights, a high-class residential district of New York City.

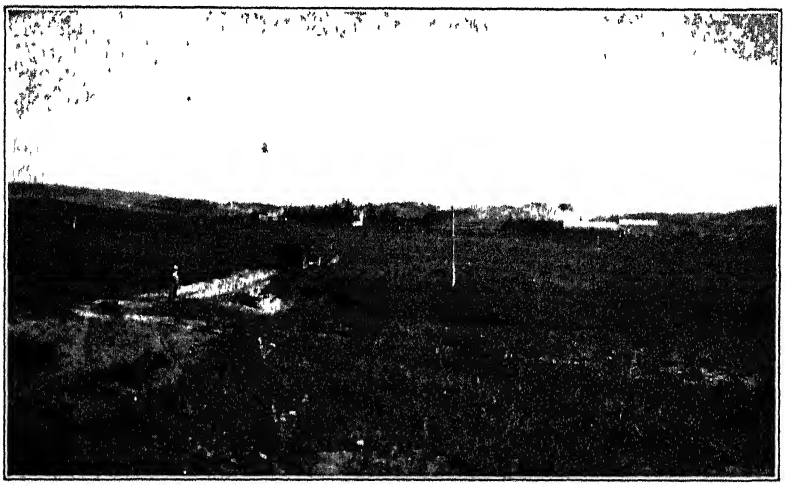


Photo by N. A. B.

Fig. 6.—A ranch home in the sparsely settled sandhill region of Nebraska.

Nevertheless, density of population should not be thought of as being wholly advantageous; it has its disadvantages as well. Crowded conditions are quite likely to entail a lack of adequate space for proper exercise and recreation. Poor housing facilities, impure air, and insufficient sunlight are not uncommon in congested centers. Under such circumstances there is danger of epidemics of disease and there is a likelihood of under-nourishment, poor lighting, and improper habits of recreation. From a social standpoint, crowded conditions have further disadvantages in that the individual is likely to become submerged in the crowd. A large percentage of the people are hired men and women, and hence in a measure are dependent upon employers. There is a tendency for the individual to become part of a highly organized social world wherein his individuality is submerged in the group, and so he loses the incentive to the independence of thought and action which characterizes the farmer or ranchman segregated from the crowd. Recreation is largely commercialized, and therefore the individual spends his leisure in effortless activities and finds but little time for quiet hours with family and friends where reading, thinking, and friendly conversation dominate. Such moments, ever treasured as precious and inspiring, are more characteristic of the country than of the crowd.

The crowd is not conducive to the development of certain types of philosophic thinking. For example, some of the finest statements of religious philosophy have come from those who lived and worked largely in solitude. Some of the greatest books of the Bible are a direct response to the quiet leisure of the shepherds of Palestine. Much of the mythology which deals with the heavenly bodies has come from the Mediterranean lands, where the nights are clear throughout most of the months and where, from prehistoric days, it has been the custom of the shepherds to keep watch over their flocks as they quietly slept on the hillsides. Midst the serenity of such surroundings, the shepherds found the canopy of the heavens their most interesting vista for observation and study. They learned to observe the stars, their apparent movements, and

their groupings; and they clothed them with the forms and qualities which their appearance suggested to fertile imaginations. One can hardly conceive of this type of activity as emanating from people who are engaged in the hurried bustle of city activities; it is a direct response to solitude under clear skies and starlit nights with ample time for thinking.

Direct social relationships.—On the other hand, sparseness of population carries with it certain characteristic handicaps, such as a tendency toward reticence and broodiness. People who live isolated lives and seldom have opportunity to converse freely with associates can hardly be expected to develop the art of eloquence One does not expect them to be oratorically inclined, but rather expects them to be quiet, almost shy in conversation, yet quick to act when occasion demands. But where people live close together, there are greater impulses to exchange pleasantries and to banter wits The cleverness of the Irish may be due in a measure to the nearness which characterizes Irish peasant life. For generations they have been accustomed to match wits with their neighbors, to vie with each other in telling stories. Out of this social life has developed the clever eloquence which is characteristic of that people today.

In matters of health, sparseness of population has some well recognized advantages, among which are life in the open, abundance of exercise, pure air, plenteous sunlight, and a freedom of activity which is not possible in the crowded sections of the cities But sparseness has disadvantages also. The lack of readily available medical attention is a serious handicap to maintenance of health Where people live far apart, such care is difficult to obtain; and therefore an inordinate amount of dependence is generally placed on various cure-alls and nostrums which are supposed to be good for all human ills, but which in too many cases are of little value for anything.

Consideration of the relative advantages and disadvantages of dense and sparse population leads one to the conclusion that a medium density is more favorable than either. Even such an assumption is but a convenient escape from a speculative com-

bat in which the conflicting facts are diverse, sometimes subtle and misleading, but always significant. Students of economic geography can ill afford to remain oblivious of the forces and factors that make for such a varied picture of the human habitat, both in quantity and quality. Trade and commerce are

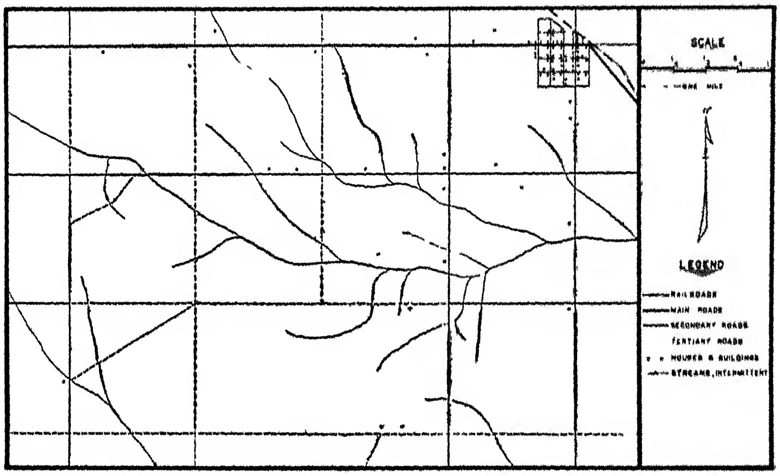


Fig. 7.—Sparse rural population on the High Plains of the United States, near Hemingford, Nebraska. (Adapted from soil survey of Box Butte County, Nebraska.)

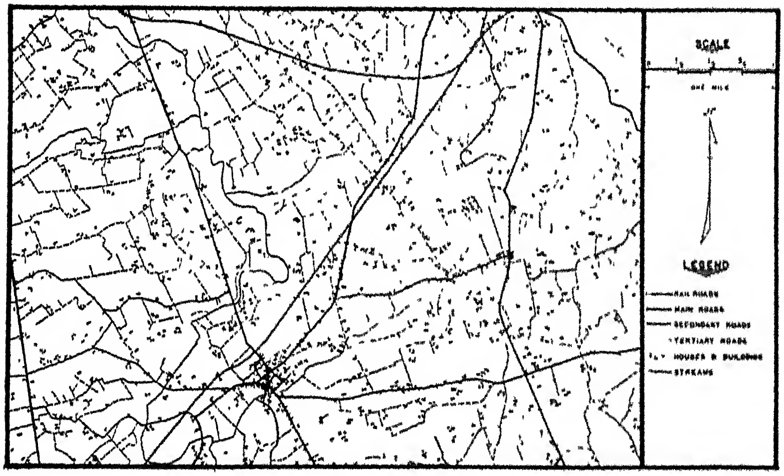


Fig. 8.—Dense rural population near Thielt, Belgium. (Adapted from topographic maps of Belgium.)

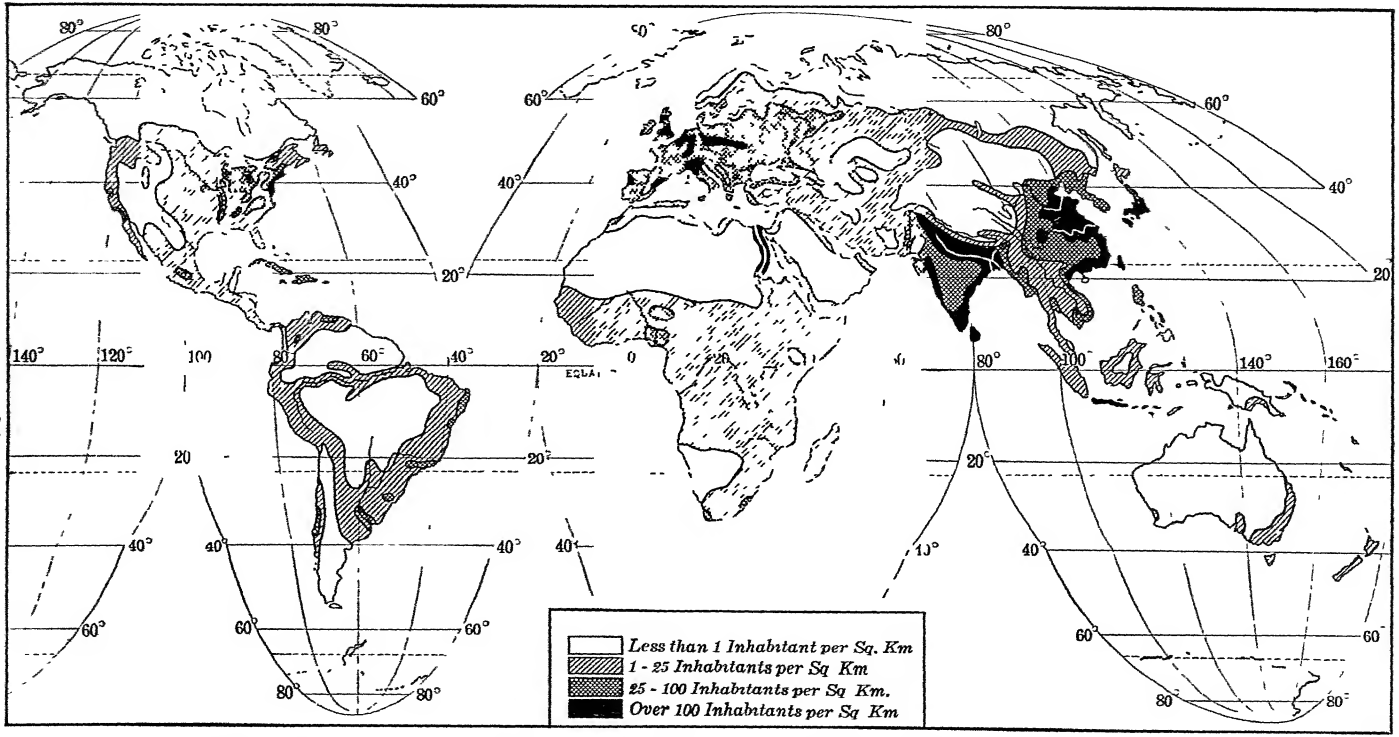


Fig. 9.—Density of population of the world, after various sources. (Goode's Interrupted Homolosine Projection, by permission of University of Chicago Press)

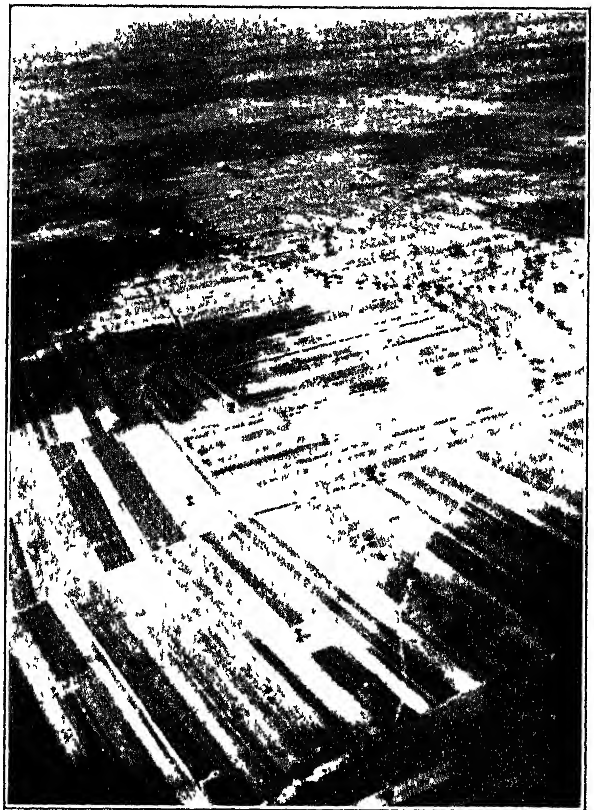
both cause and result of such manifestations. Therefore, a survey of the distribution of populations in the various grand divisions of the earth is helpful not only in acquiring a concise world view as to where people live, but also in appreciating some of the fundamental factors which underlie world trade.

Population areas in Asia and the East Indies. Asia is generally regarded as the original home of man, and may therefore be termed the most ancient of the continents from the standpoint of human occupation. Notwithstanding its ancient occupancy, people are distributed quite unevenly over the continent. Some of the most congested districts in the world are found there, as are also some of the most sparsely peopled areas. The valleys of the Ganges and the Brahmaputra of India and the lowlands of eastern China support the most congested agricultural populations in the world today. The southern islands of Japan may be considered to be an extension of the Chinese centrum of density Java is a conspicuous example of great density in a region where sparseness prevails and where but few of the neighboring islands show more than a moderate population. That Asia as a whole, however, is not densely populated is well shown by the fact that more than half of the continent has a population density of less than two per square mile. Vast areas are conspicuous for their few folks and great distances, thus standing out in sharp contrast with Java, the Ganges Valley, and the plains of eastern China.

The change from dense to sparse population is abrupt westward from the plains of China and northward from the valley of the Ganges. There the shifts from denseness to sparseness occur within short distances. The questions naturally arise, "Why such pronounced extremes? Why are the shifts from one condition to the other so abrupt?"

In some cases the explanation is quite simple For example, north of the Ganges Valley rise the extraordinarily high and rugged Himalayas and the inhospitable mountains and plateaus of Tibet The valley plain gives way suddenly to the steep, forested slopes of the mountains; population density must necessarily respond. In China, however, the reasons are

not quite so obvious. Going westward from the lower valleys of the Yangtze and the Hwang Ho, changes in topography and climate are encountered, but they are not so abrupt as the change in population distribution might suggest. Ruggedness is a limiting factor in some degree, but the topography is

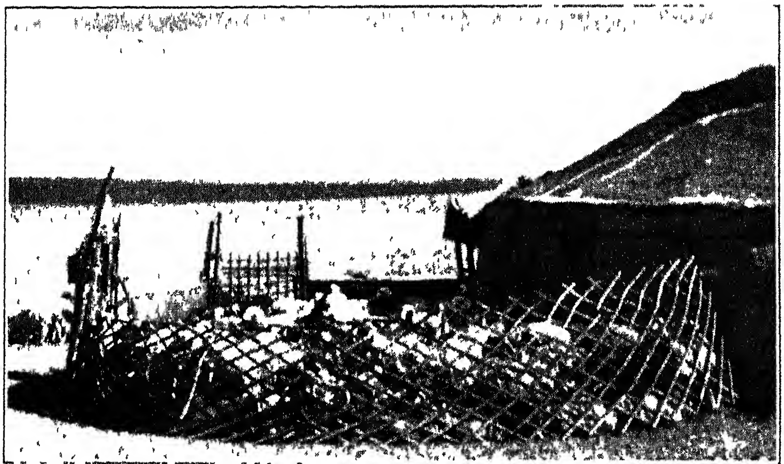


Courtesy, Dr George B Barbour, Yenching University, Peiping, China

FIG. 10.—Airplane view of densely occupied agricultural land on the delta plain of the Hwang Ho, China. Strips shown represent individual fields. Dark patches are shadows cast by clouds

neither so rugged nor so nearly insurmountable as are the mountains which border northern India. The climatic change from humid conditions to semi-arid is probably the most important factor, but such change is gradual. The outstanding reasons for the sharp change in population density appear, therefore,

to be based on the methods of land utilization rather than upon climate and topography. Where farming is done largely on an intensive, hand-labor basis, as in China, only highly productive lands can be utilized. Large production per acre is necessary because by hand labor each worker can till only a small area, and the return from that area must be sufficient to provide his necessities of life. Where good soil and sufficient rainfall occur, such necessities can be provided for many people; but the areas where high production is possible by intensive non-irrigated agriculture are sharply delimited. When the



Courtesy, American Museum of Natural History, New York *Photo by Roy Chapman Andrews*

Fig. 11.—Region of sparse population due to aridity, Mongolia, Asia. Sheep and goat corral in foreground.

line of critical rainfall for food crops is passed, production on the land that can be tilled by the individual is insufficient for his support and hence he cannot live there. Peoples who farm with machinery and power can to a large degree adapt their methods to the climatic conditions. Lower productivity per acre is offset by more acres, and this leads to a gradual transition from thickly settled to thinly settled lands, and finally to sparseness. Not so with the hand-labor farmer; his methods are inelastic and hence are not adapted to large areas per man. Consequently, the transition zone from production to non-produc-

tion of food grains is narrow and pronounced where moisture dwindles. Denseness gives way abruptly to sparseness

Contrasts in population density in Asia are not limited, however, to contrasts in topography and climate Areas of similarity in physical features may differ in population density because of differences in types of settlement, in kinds of industrial activities, and in the qualities of the people. Stage of industrial development, history of settlement, and accessibility also are important factors to be considered.

On the whole, however, Asia presents sharp extremes of population density in contrast with the gentle gradations which prevail in Europe It is a continent of extremes in land forms, in climatic conditions, and in agricultural productivity It is perhaps a fitting consequence that it is also a continent of extremes in population density, one where congested areas contrast sharply with areas of sparseness.

Population areas in Europe.—As may be noted from the population map (Fig. 9), Europe presents a more diversified pattern of population distribution than any other continent The area of dense population extends from Ireland and England across northern France, Belgium, and the Netherlands through the heart of Germany and Poland into a portion of western Russia. This is flanked by broad belts of medium population on the north, east, and south before the strips of sparseness are reached in the far north of Europe and along the lowlands bordering the Caspian Sea. The chief centers of maximum density are found in England, northeastern France, Belgium, and the adjacent portion of Germany, while there are important islands of density in Portugal and northern Italy In the areas mentioned, even though the great cities be not included, the population is over a thousand per square mile. In general, these areas of maximum density of population are characterized by industrial activities

Contrasted with the industrial districts above noted, which contain some of the most thickly populated areas of the earth, are the backbone of Scandinavia and the plains of northern Finland and Russia, where there are less than two people

per square mile. Similar sparseness is found also on the dry plains of southeastern Russia. Islands of sparseness caused by ruggedness exist in Scotland, Spain, Switzerland, northern Italy, and east of the Adriatic. Generally, however, the change from one extreme to the other occurs gradually, and wider zones of medium density occur between the extremes than in any other grand division of the eastern hemisphere.

Population areas in Australia.—Australia has no centers of

Courtesy, Official Secretary for Australia in U. S. A., New York.

Fig. 12. Sparsely settled grazing area in Queensland, Australia. In Australia, sheep and cattle ranches are called "stations."

great congestion. Aside from the few large cities, the population is scattered. The southeastern portion of the continent and the extreme southwest corner are the only sections which have a population in excess of 25 per square mile. Approximately four-fifths of the continent has less than two persons per square mile.

The small population of Australia is due to the dry climate of a large part of the interior; to the warm, rainy jungle of the equatorial northern section; and to the newness of settlement.

Without doubt, Australia is capable of supporting a population considerably larger than it now has. There are areas of transition lands from jungle to desert, from lowlands to highlands, and from warm lands to temperate lands that remain but slightly used. Their development awaits social and economic demand.

Population areas in Africa.—A much larger percentage of the total area of Africa carries a population of from 2 to 25 per square mile than is the case in either Asia or Australia. Africa has but one important centrum of dense population, namely, the lower Nile Valley. Centers of medium population are found in South Africa, along the Gold Coast, and along the western Mediterranean. The greatest areas of sparseness are the Sahara Desert and the Kalahari Steppe and Desert, in both cases aridity being the controlling factor

With the exception of the lower Nile Valley, gradations from medium density to sparseness are well-shown in Africa The general situation is almost the reverse from that which exists in Asia and Australia. The medium density of population which characterizes much of Africa is a factor of economic significance. Some people are found in nearly all parts of the continent, except in its extreme deserts, and a large percentage of them are energetic and capable of becoming efficient workers. Africa is therefore looked upon with favor as a promising field for successful exploitation, not only because of its resources of mineral wealth, its productive agricultural and timber lands, but also because it has a native population which can be made to serve as an economic asset for industrial projects.

Population areas in South America.—South America has only two large centers where the population averages above 125 per square mile; namely, the Rio de Janeiro-Santos region of Brazil and the lower Plate River district of Argentina and Uruguay. Neither of these areas is extensive, and both owe much of their density of population to the presence of the large cities included within them With respect to distribution of population, South America bears much resemblance to Africa in that the interior of the continent is for the most part sparsely

settled and the principal cities and areas of relatively heavy population are not far from the coasts. The two continents are similar in that the larger portions of their areas lie within the Torrid Zone, and thus warm climates are conspicuous features of each. Topographically, however, they differ greatly. Africa presents a plateau aspect, whereas South America is principally a lowland with a narrow strip of lofty mountain ranges along the western margin and with lower, less impressive mountains along parts of the northeast and the southeast coasts.

While sparseness in Africa is due largely to aridity, in South America the two largest areas of sparse population are within the drainage areas of the Amazon and the Orinoco Rivers, where the rainfall is heavy and the vegetation cover impressive. The west coast of middle South America together with the adjacent slopes into the mountain upland is a pronounced desert, but this area is not so extensive as is either the great Sahara or the Kalahari of Africa. Southern South America constitutes the fourth large area of sparseness on the continent, a response to aridity, cold, and remoteness.

The most densely populated areas of South America are conspicuously the most progressive. Such areas, worthy of special emphasis, center about Rio de Janeiro and Santos, Montevideo and Buenos Aires, Valparaiso and Santiago, Lima, Bogota, and Caracas. In a continent as large as South America, with tremendous resources awaiting development but with serious natural obstacles to be overcome in order to assure industrial progress, it is inevitable that fewness of people is a serious drawback to exploitation.

Population areas in North America.—North America has but one large area of dense population. It is located in the east-central part, and is surrounded by a broad band of medium density which leads to vast areas of sparseness in the north and west and to smaller areas in the south. These contrasts in density of population are natural responses to the vastness of the area and to the differences which characterize the natural conditions of the continent. Climatically, North America

ranges from the Arctic to the Tropics; and topographically, from low, flat, poorly-drained coastal and alluvial plains to large areas where mountain ruggedness prevails, with peaks rising to altitudes above 14,000 feet. Between these extremes are intervening stages of plain, plateau, and mountain, so that the natural landscape presents nearly all the aspects shown in any part of the world From the standpoint of population distribution, the unique feature which deserves emphasis is the extent of its transition zones from areas of high density to those of sparseness.

Canada—Sparseness is the dominant characteristic of the distribution of people in Canada. The country as a whole averages only a little more than two persons per square mile. The only area of relatively high density is along the St Lawrence River and in the southern part of the peninsula of Ontario. There the large cities of Toronto, Ottawa, Montreal, and Quebec, together with scores of important smaller places, and a well-developed agricultural industry, serve to create a moderately extensive area wherein the density reaches 25 to 60 people per square mile. Flanking this area is a narrow transition zone on the north, which broadens greatly toward the northwestern interior. In this transition belt, the population averages from 25 to 30 per square mile down to below 5, and beyond this belt few people live. Ninety per cent of the total area of Canada and Labrador has less than two inhabitants per square mile.

Sparseness of population in Canada is due in large measure to the inhospitable cold of the northern part of the country and to the rugged mountain topography of the west, but between the areas which must permanently remain extremely low in productivity and the areas which are now well populated is a zone of relatively large potential production wherein few people dwell. The plains of the prairie provinces of Canada are only partly occupied. The chief reason for sparseness throughout this broad belt is the pioneer stage of settlement Economic pressure in congested areas has not yet forced surplus population into these productive parts of Canada

The United States.—The average population density of the

United States is slightly above 40 per square mile. The country has no extensive areas of dense population such as are found in northwestern Europe, northern China, and India. In general, the population is widely scattered and there are broad transition zones between the areas of congestion and those of sparseness. In this respect the country bears a marked resemblance to Europe.

There are three major areas of high density of population within the United States: namely, (1) the Atlantic seaboard metropolitan area, embracing the territory between Boston and Washington and including those cities together with New York, Philadelphia, Baltimore, and a score of other large cities nearby; (2) the Lake Erie-western Pennsylvania area extending from Detroit to Pittsburgh and including the cities of Toledo, Cleveland, Buffalo, and Youngstown and contiguous territory; and (3) the upper Lake Michigan area including Chicago and its adjacent cities, and extending from Milwaukee southward to Indianapolis. Islands of density within the United States are chiefly city centers, such as St. Paul and Minneapolis, St. Louis, Los Angeles, and San Francisco All these areas of density of population in the United States, as in Europe, have developed as a result of industrialism rather than of agricultural activity, and in this respect stand in sharp contrast to the population centers of China, India, and Java.

Areas of sparseness in the United States are in the southern Great Plains, in the Rocky Mountains, and in the inter-mountain basins and plateaus of the southwest. These are the results of ruggedness and of aridity. The productive lands throughout the country carry a medium density of population.

Areas of denseness and of sparseness in the United States are on the whole widely separated; between them, great areas carry a population ranging from about 5 to 60 per square mile, and in this fact lies one of the reasons for the material well-being of the people of this country. Most of the land of the United States is being used, not to its full capacity perhaps, but nevertheless it is producing and the productivity per man is relatively high. The highest grade agricultural lands are char-

acterized by small farms and methods of intensive production, whereas in drier lands, or where for other reasons the land is less productive, large farms and ranches prevail. In the latter case the production per acre does not average so high, but this is offset by the greater number of acres tended by each worker, as a result of which production per man remains large. In other words, the marginal lands of the United States are contributing to the welfare and prosperity of the people of the country, a condition made possible by the use of large-scale methods of farming dependent upon power from animals or gas engines rather than upon man-power only. The results stand out in

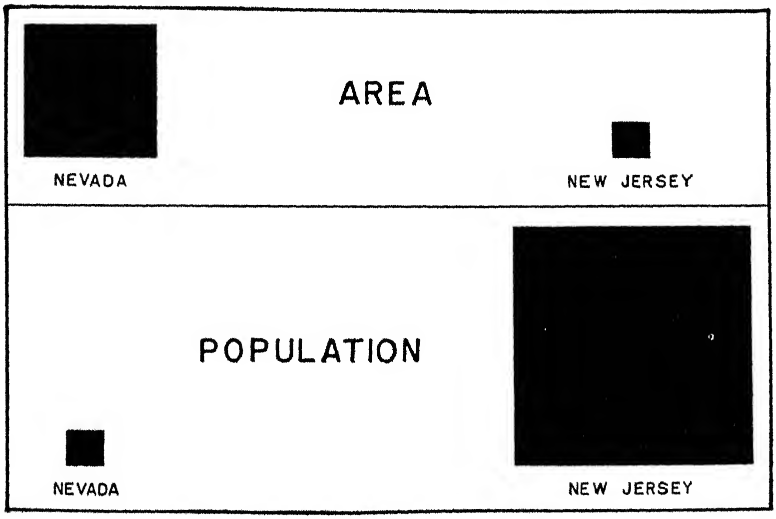


Fig. 13. - Comparisons of area and population of Nevada and New Jersey.

contrast to the conditions in the semi-arid districts of China, where similar lands lie unused because of the absence of efficient methods of extensive production.

Mexico.—The average population of Mexico is about 18 to 20 per square mile. The country has only one area of comparatively dense population: namely, the valley of Mexico, wherein lies Mexico City. In parts of that area the population averages 25 to 60 per square mile. On the other hand, most of Mexico carries a scattered population averaging 2 to 25 people per

square mile, most of whom live in small villages and depend chiefly on agriculture for their sustenance.

The center of density in the valley of Mexico is due to Mexico City, its suburbs, and adjacent small towns. This is in no small way a response to the productivity of the land in that section of the country. The soil is fertile and the rainfall, about 23-24 inches per year, is sufficient to support fairly intensive agriculture. Water is available for irrigation in some parts of the valley; and since the city furnishes good markets for products, intensive production of foodstuffs is particularly remunerative.

Sparseness in Mexico is due to aridity in Sonora and in the northeast, but in Yucatan it is not so easily explained. That the land is not highly productive is probably true, but that it is capable of supporting a much larger population than now lives there seems certain. The pressure for land has not been sufficient to overcome the difficulties of clearing the jungle.

Summary.— "Where do people live?" is thus a question rather easily answered. It is evident that each great land mass exhibits a few limited areas of high density of population and vast areas of sparseness. Most of the people of the world live on a small percentage of its land surface, while a large percentage of the land supports few people and makes but little contribution to the material prosperity of the present age. Extensive areas of moderate density of population are found only in Europe and North America. All the grand divisions have vast areas of unused land.

"Why do people live where they do?" is not so easily answered. Density of rural population is possible only on lands capable of yielding large returns per acre under intensive methods of production. This involves productive soil, long growing season, and generous rainfall. Eastern China, Java, and Ireland are familiar examples of heavily populated agricultural areas. Power resources and availability of industrial raw materials, coupled with accessibility to great markets, make a combination of factors which tend to create heavily populated urban areas Familiar examples of the latter kind are the industrial centers of northwest Europe and eastern

United States. The Nile Valley is a well known district where irrigation is the key to population density. The human factor also needs to be taken into consideration. Some people are unwilling to leave their familiar homelands, congested though they may be, for more spacious and perhaps greener fields. Only dire necessity can force migration in such cases, and therefore congested areas feed their surplus very slowly into available areas of sparseness Another factor which tends to maintain the present status is racial prejudice coupled with political power. The yellow peoples would probably be more widely dispersed if the whites had not established barriers against them. It is apparent that the *why* of where people live is a question that cannot be answered in broad generalizations. Each area must be considered as a separate unit.

"What are the consequences of the uneven distribution of people over the world?" is an intriguing question, but one not readily answered Important consequences of these contrasting conditions of population are expressed in their relations to markets, sources of goods needed by the rest of the world, and to transportation problems which confront industry and commerce in the various sections of the continents. Where distances are as great as in the sparsely settled interior of China, unavailable markets furnish little incentive for the production of a surplus. Imports are nearly negligible because of the high cost of transportation and the lack of means wherewith to buy In areas of congested population, as in eastern China, surplus products of handicrafts are available at relatively low prices because the numerous workers are paid small wages, and the standards of living are low. Markets for imports are limited by the low purchasing power of individuals, although, because of the large numbers, the aggregate may be large in spite of the low per capita purchases.

Frontiers are on the borderland of productive regions. While the expansion of industry and the intensification of agricultural pursuits tend to diminish for a time the pressure of population, continued increase in numbers will ultimately necessitate readjustments of distribution of people. Such readjustments

will press upon existing frontiers and establish new ones. Migrations of Europeans into colonies in North America far detached from their homeland were in progress for nearly three centuries prior to 1900. Such migrations into Canada, South America, and Australia, are still in progress. The probabilities are that this movement will continue for decades to come and that Africa will be added to the list of large-scale colonial territories.

In these changes and movements the character of the natural landscape will always be an important influence in guiding progress, and it will present problems which man must solve if he would succeed. Economic geography must therefore give serious study to the qualities and characteristics of the land if it would assist in solving the problems incident to such readjustments Climatic conditions must be studied, because they bear direct relationships to human activities. Industrial, agricultural, and social changes always involve shifting frontiers. Efficient adjustment of agricultural and industrial activities to the factors of the natural landscape is essential to economic welfare.

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CHAPTER III

Our Earth

"WE don't know where we are going, but we are on our way." It probably did not take you more than a second to read the preceding sentence, but in that moment you travelled with the earth about 18½ miles in its path around the sun. This figure may not appear startling, but a simple calculation will show that it means a speed of between 80,000 and 90,000 miles per hour, whereas our fastest airplanes travel less than 500. Furthermore, the rotation of the earth on its axis, and more especially the rapid movement of the sun and earth toward some unknown destination among the stars, give us a total velocity much greater than the figures stated. Just how many miles we travel through space in the course of a year cannot be computed with certainty. Suffice to say that this is really a fast old world

The nature of the earth and its relationship to the sun are of utmost importance if we wish to understand the material basis for man's life upon the globe. The existence of conditions favorable to organic life in general and human life in particular, the continual changes from day to night and from night to day, the great differences in climate and therefore in living conditions in various parts of the world—all these and many other facts and circumstances which directly affect mankind are the immediate results of the place and the movements of the earth in the solar system

Form.—Restricted powers of observation led early man to believe that he inhabited a flat body, either round or oblong. Long before the Christian Era, however, keen observers decided that the earth was a sphere Pythagoras, a Greek philosopher who lived about 500 B. C., seems to have been the first exponent

of this conception, although only on purely philosophical grounds. Aristotle, who lived about 350 B. C., first drew attention to various phenomena which indicate a spherical form of the earth. In the light of these facts it seems unfair to credit Columbus with being the originator of a new, revolutionary idea in world geography. His great achievement was that he first applied what others had taught.

Today we know that the form of the earth approaches a sphere with a diameter of nearly 8,000 miles, and a circumference of a little less than 25,000 miles Since the earth is slightly flattened at the poles, we usually refer to it as a spheroid. Much depends upon our point of view. As a celestial body, the earth is but a speck of dust in the endless space of the universe. As man migrates back and forth on the tiny speck, it assumes, however, rather huge proportions. The volume of this spheroid is about 260,000,000 cubic miles, its surface about 197,000,000 square miles. We can spend a lifetime wandering about and see but a fraction of what the world has to offer.

The migratory instinct of man, the needs of trade with distant lands, and man's desire to explore and describe, early created a need for some method whereby it would be possible to state accurately the location of places. On a spherical surface the problem of location is a difficult one, since no fixed points are available. However, since the earth rotates on a permanent axis, the terminals of this axis, known as the poles, provide convenient fixed points for the creation of a network of lines with which it becomes possible to fix the location of any place on the surface of the globe. This network consists of two sets of lines intersecting at right angles. The *meridians* extend in north-south directions converging toward the poles and diverging toward the equator. The *parallels* extend east-west, and any two are of course equidistant throughout their extent. The *equator* is a great circle dividing the earth into northern and southern halves and therefore is the initial circle, latitude 0°, for reckoning distances north and south. As an initial meridian from which to reckon distances east and west, the site of the well-known naval observatory at Greenwich (London) was

chosen by international agreement, and therefore it has become recognized the world over as the Prime Meridian, longitude 0°. From it others are reckoned eastward to longitude 180° E. and westward to longitude 180° W.

Revolution of the earth.—Insolation, the heat and light re-

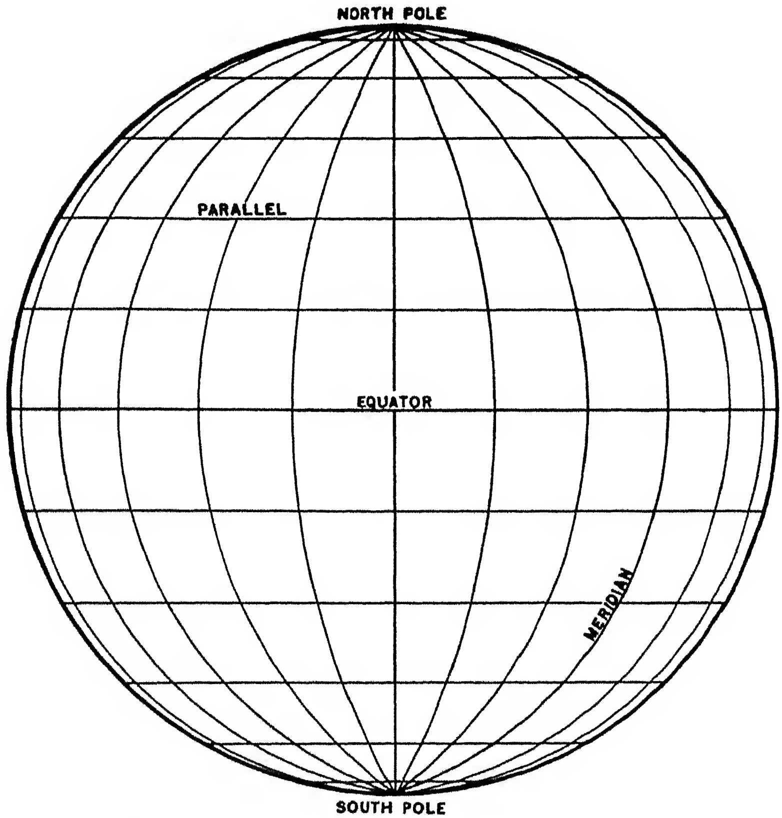


Fig. 14.—Hemisphere showing parallels and meridians.

ceived from the sun, makes the earth habitable. Insolation is unevenly distributed, and for any one place is subject to seasonal fluctuations. Some parts of the earth, as near the poles, are predominantly cold, whereas other parts, as near the Equator, are predominantly warm. In still other parts, particularly in the middle latitudes, warm seasons alternate with cold year-

ly. These phenomena are due to the revolution of the earth in its orbit, which determines the length of the year, and to the inclination of the earth's axis ($23\frac{1}{2}$ degrees) to the plane of its orbit. These conditions have had far-reaching effects upon the development of the human race; they determine in large measure how and where man may live and the kinds of activities in which he may engage.

Insolation in relation to varying distance of the earth from the sun.—The orbit of the earth's movement about the sun is an ellipse rather than a true circle, and therefore the distance

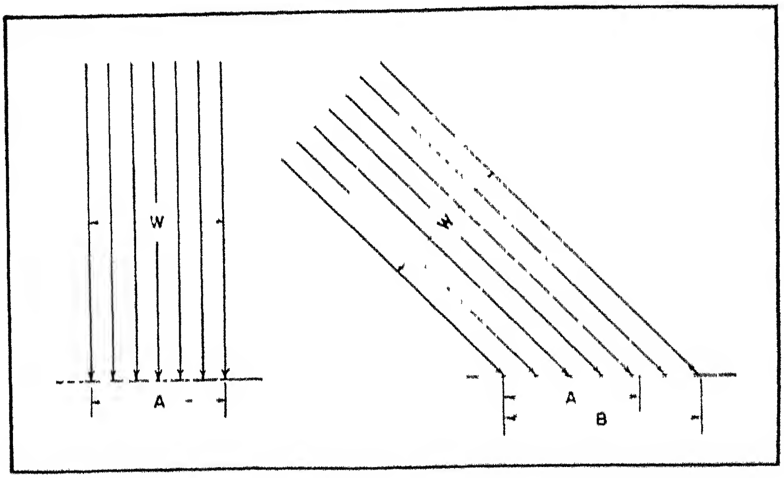


Fig. 15. Diagram of the sun's rays striking the earth vertically and obliquely. The diameters of the bundles of rays are equal. Note that the area heated by slanting rays (B) is much larger than that heated by vertical rays (A).

of the earth from the sun varies during the year. In December the earth is about 3,000,000 miles nearer the sun than in June, but this difference in distance is so slight in comparison with the average distance of the earth from the sun (about 93,000,000 miles) that it has no appreciable effect upon the amount of heat received daily during the year. The position of the earth in its orbit when nearest the sun, that is, in the northern winter, is called *perihelion;* when farthest from the sun, that is, in the northern summer, it is called *aphelion*.

Insolation in relation to the sphericity of the earth.—The great differences in the amount of heat received annually at places near the equator and at places remote from it are due to the sphericity of the earth. A bundle of light rays will illuminate and heat a much smaller area if it shines upon it at right angles than it will if it strikes a similar surface more obliquely If the rays are concentrated upon a smaller area, the intensity of heating and lighting is of course much greater than if they are dispersed over a larger area. Thus the angle at which the

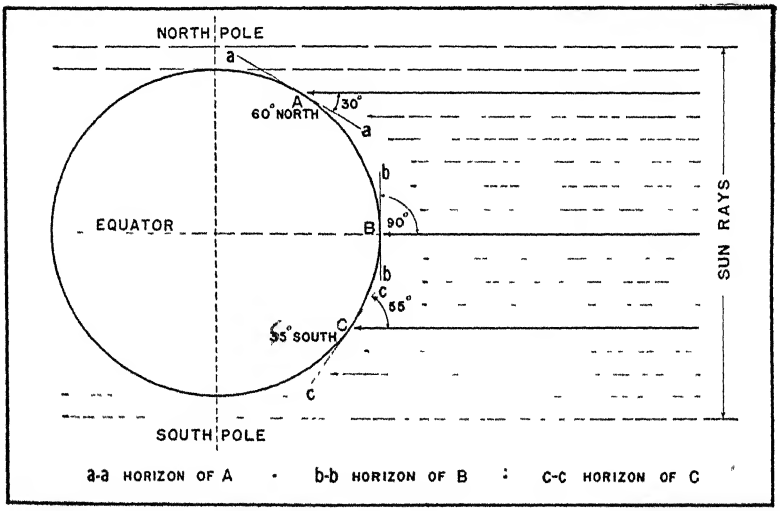


Fig. 16. Diagram of the sun's rays striking the earth during the equinoxes The altitude of noonday sun above the horizon shown specifically for three different latitudes.

rays of the sun strike the earth's surface is highly significant. Near the equator the rays shine almost vertically upon the earth at noon, whereas in the higher latitudes even the noonday sun strikes the surface quite obliquely. On their way through the atmosphere the sun's rays lose some of their energy through absorption, dispersal, and reflection. The farther they travel through the atmosphere, the greater this loss. It is evident that toward the poles, where the sun's rays cross the atmosphere more and more obliquely, the loss sustained is much greater than near the equator. As a logical result of the fore-

going facts, average annual temperatures on the earth generally decrease from the equator to the poles.

Seasons.—The amount of heat which each spot on the surface of the earth receives varies during the course of a year. This causes great periodical differences in temperature over large parts of the earth, and thus gives rise to summer and winter seasons This is a direct result of the fact that the axis of

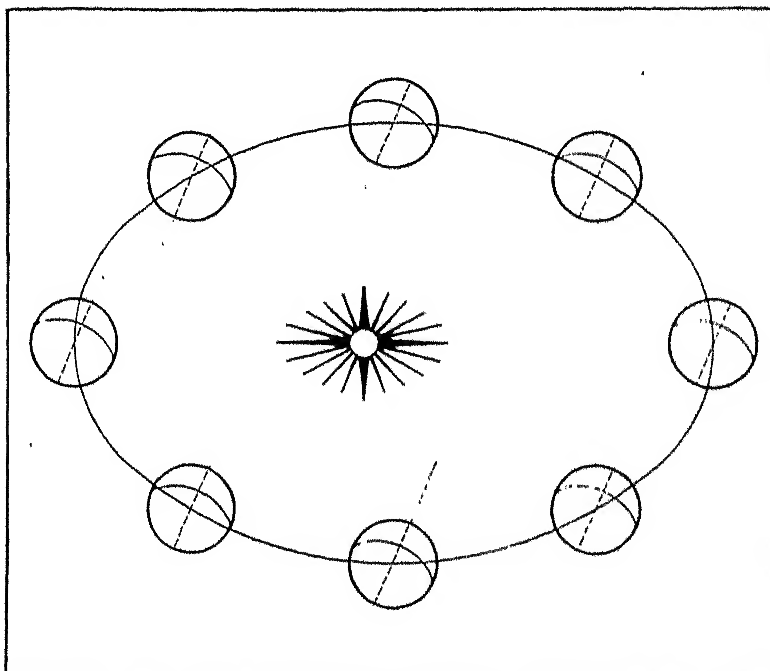


Fig. 17. -Sketch to show parallelism of the axis in all points of the earth's orbit.

the earth is not at right angles to the plane of revolution, but is inclined toward it at an angle of 23½ degrees. Both the inclination and the orientation of the axis are persistently maintained during the entire revolution of the earth around the sun, so that in any position of the earth in its orbit the axis is parallel to all its previous and prospective positions. The North Pole of the earth always points toward the North Star, Polaris.

Because of the inclination of the axis of the earth toward the plane of its orbit, the Northern and Southern Hemispheres are alternately the more directly exposed to the sun On the 22d of June the position of the axis is such that the Northern Hemisphere is turned toward the sun Thus the rays of the sun strike the surface of this hemisphere at relatively large angles, up to 90 degrees. The high position of the sun in the sky makes for greater insolation north of the Equator, and consequently the season is warm and is termed summer by northern people. During this same period the Southern Hemisphere is turned away from the sun and the solar rays strike it at comparatively smaller angles. As the sun stands relatively low, the effectiveness of its rays is less, and temperatures are lower. It is the winter of the Southern Hemisphere.

The inclination of the earth on its axis causes seasonal variations in the apparent positions of the sun in the sky At noon on the 22d of June the sun strikes at an angle of 90 degrees in the latitude of 23½° N. This parallel is named the Tropic of Cancer. Conversely, on the 22d of December the sun stands vertically above the parallel of 23½° S., named the Tropic of Capricorn. These dates are known as the solstices because in connection with them are a few days in each instance when there is but slight change in the daily period of sunlight. June marks the period of the summer solstice in the Northern Hemisphere and of the winter solstice in the Southern Hemisphere. December, on the other hand, is the period of the winter solstice in the north and of the summer solstice in the south. Twice yearly, about March 21 and September 23, the sun stands vertically over the equator, midway between the two tropics. We speak of these dates as the equinoxes, because days and nights are then each of twelve hours duration all over the earth. Between March 21 and September 23 the sun rises north of east and sets north of west, whereas from September 23 to March 21 the sun rises south of east and sets south of west.

Since it takes time for the earth to heat or to cool, the highest summer temperatures in the Northern Hemisphere commonly do not occur until after June 21, as also the lowest temperatures

generally do not occur until well after December 22. At the Equator and approximately as far north and south as the Tropics of Cancer and Capricorn respectively the noonday sun is never very low in the sky. Consequently this part of the earth's surface is relatively warm all year. The seasons are characterized not so much by differences in temperature as by fluctuations in the rainfall during the course of the year. Vegetative growth never entirely ceases, although in some sections of this zone the occurrence of an annual dry season may cause most of the trees and shrubs to shed their leaves, thus creating a landscape similar in some respects to that of the northern winter.

In the middle latitudes there is a pronounced temperature contrast between the period during which the noon sun stands high and that during which it stands low in the sky. In these regions we have a true summer and a true winter. The summer is the growing season, the winter is the season during which the entire vegetation is inactive for lack of sufficient heat. Near the poles the temperatures are so low even in the warmer half of the year that vegetative growth is impossible. These are the areas of perpetual ice and snow.

If the axis were not inclined. Were the earth's axis not inclined there would be no seasons. The world would be markedly different from the one we inhabit. The warm belt would be a narrow band of excessive heat gradually merging into cooler areas to the north and south. There would be no regions with alternating summers and winters. The frozen wastes about the poles would extend farther equatorward than they do now. Days and nights would be of equal length everywhere. At any given place the daily insolation would remain unchanged throughout the year. It is difficult to visualize such a world, one of unending climatic monotony in contrast to the stimulating diversity which is our present condition. From our present point of view it seems unlikely that any highly developed, complex scheme of civilization could come into existence under the deadening influence of such monotony of climate as would then prevail. Diversity of climatic conditions seems essential to progress.

Rotation of the earth.—The phenomenon resulting from the inclination of the earth's axis (*i. e.*, the variation in insolation) is complicated by the fact that while revolving around the sun the earth rotates on its own axis. The rotation of the earth on its axis once in 24 hours gives within that period heat and light as well as darkness to most parts of its surface. The sun appears to rise in the east, to travel across the sky, and then to set in the west. Actually, however, the earth is turning in the opposite direction, from west to east. Deception in such matters is often experienced. Who has not had the sensation of moving while seated in a Pullman, only to discover a little later that the train on the next track was slowly pulling out of the station?

The change from day to night causes minor fluctuations in temperature. During the day insolation ordinarily raises the temperature about us. At night part of the heat accumulated during the daytime is given off, radiated into space. The temperature in any given spot of the earth is generally highest in the early afternoon, and lowest just before sunrise. These daily fluctuations are of considerable economic importance. They prevent excessive heating. In many parts of the world the nights give some respite from the heat of the daytime. In the spring the daytime temperatures may be favorable for plant growth, but the low temperatures of the early morning often bring with them the danger of frosts.

The significance of rotation can best be appreciated if we picture the results which would follow from its absence. We would still have summer and winter, but not day and night. The day would be six months long, marked by a continuous presence of the sun in the heavens. Uninterrupted insolation would cause the summer season to be an inferno, excluding all life. Conversely, darkness would be six months long, and during that period surface temperatures would probably resemble those found now only in polar areas during their winter periods. In short, a non-rotating earth would make for such extreme climatic conditions that life, as we know it, could not exist.

Unequal lengths of days and nights. If the earth rotated on an axis standing vertically on the plane of its orbit, days and nights would always be of equal length Since the axis in inclined at an angle of 23½ degrees, the respective lengths of day and night vary in the course of the year. In the Northern Hemisphere the days are longer in June than are the nights, in December the reverse holds true. The longer period of insolation during the summer in the middle latitudes, followed by only a brief period of cooling during the night, tends to make summer temperatures even higher than they would be, owing to

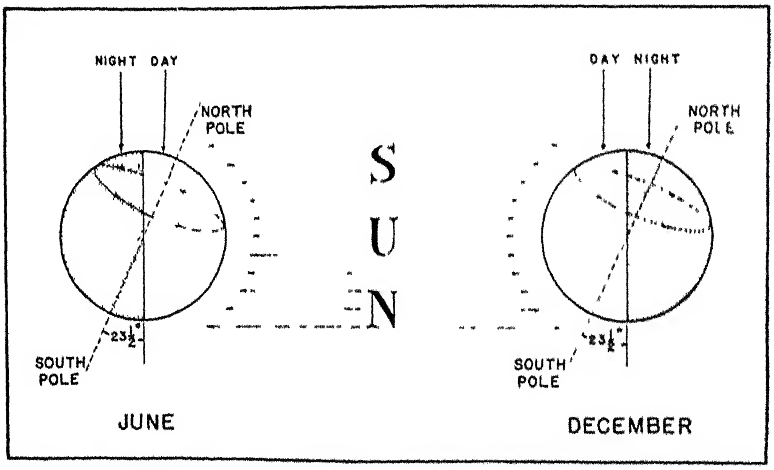


Fig. 18. Diagram showing day and night in June and December

the higher position only of the sun. In the winter season the prevailing low temperatures are accentuated by the shortness of the day.

While near the equator the difference between the length of day and night is relatively slight, toward the poles it becomes steadily greater until, beyond the polar circles, there are both a polar day and a polar night of increasing duration. As a result of the low position of the sun in such high latitudes, even during a polar day of several months, temperatures do not go much above the freezing point.

Reckoning of time.—The sun reaches its highest position of

road and telegraph, the old system soon fell into disfavor. A standardized time scheme became necessary.

Since the sun crosses 360 degrees of longitude in a period of 24 hours, it crosses a belt 15 degrees longitude in width in one hour. By adopting the noon instant of the middle meridian, the maximum deviation from the true local noon does not exceed 30 minutes anywhere within the belt. This is the basis for the division of the country into standard time belts, and within them the solar time of the central meridian is arbitrarily accepted as the correct time for all places. Thus in the United States, Eastern Standard Time is based on the meridian of 75° W. longitude; Central Standard Time on the 90° meridian, Rocky Mountain Standard Time on the 105° meridian, and Pacific Standard Time on the 120° meridian. Europe has three time belts, corresponding to our belts of standard time: Western, Central, and Eastern European time. Theoretically, such time belts should be confined strictly within 7½ degrees on either side of the standard meridian. But since population centers recognize no such boundaries, practical adjustments to problems of individual cities and also to transportation problems sometimes make it necessary to set aside strict observance of the theoretical limits. Therefore the boundaries of the time belts are irregular and only approximate the ideal (Fig. 19.)

The International Date Line. The previous paragraphs have made clear that around the world different clock hours occur simultaneously. When it is noon at London it is past noon east of there and before noon west of there. Likewise, when it is midnight at London it is past midnight at places east and before midnight at places west. Thus when Big Ben strikes the midnight hour at London on Saturday night, places to the east have Sunday whereas to the west Saturday still persists.

It is obvious that somewhere on earth every new date must appear first. By international agreement, the 180th meridian has been chosen as the place where each new date first begins. The International Date Line thus selected makes deviations from the 180th meridian only where land areas are crossed. Thus every calendar date *first* appears on earth when it is mid-

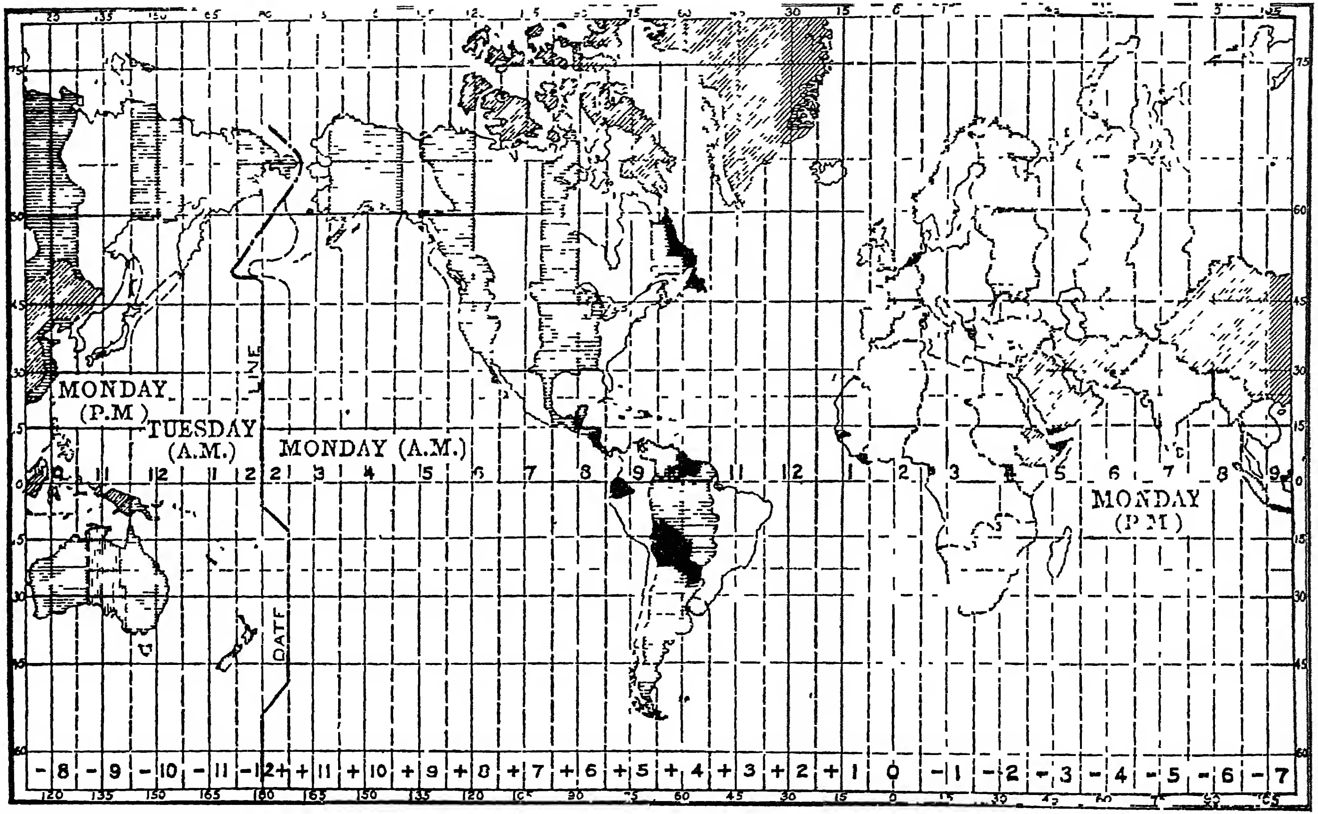


Fig. 20.—Time belts of the world. (Adapted by F. A Carlson from *Time Zone Chart of the World*, Hydrographic Office, Washington, D. C., eighth edition, 1933.)

night at the International Date Line. Inasmuch as the earth rotates from the west toward the east, the midnight line travels westward from the International Date Line, carrying the new date with it. Thus just west of the International Date Line the new date appears 24 hours sooner than it occurs just east of the line For example, when it is Tuesday west of the line it is still Monday east of the line, and will so continue until the midnight hour reaches there. Since the new date first arrives just west of the Date Line and then proceeds westward as the earth rotates, a complete rotation, involving 24 hours of time, is necessary to bring the same date to points just east of the line. With the completion of one rotation, Tuesday has been begun over all the earth, and then Wednesday is begun west of the line and the sequence is repeated. It is well to impress firmly upon the mind that every new date first appears on earth when it is midnight at the International Date Line, and that it follows the midnight line around the world from the Date Line westward to Japan, continental Asia, Europe, and thence across the Atlantic to New York, Chicago, San Francisco, and again into the Pacific.

The spheres of the earth.—The earth includes, technically, the air and the water as well as the solid part of our planet. Defined thus broadly, we speak of it as consisting of three principal spheres: the air sphere, the water sphere, and the rock sphere; or, respectively, the *atmosphere*, the *hydrosphere*, and the *lithosphere*.

The realm of life lies in the zone of contact of these three spheres. There life exists most abundantly, and diminishes in variety and quantity as the limits of that zone are approached. There is no life in the higher portions of the atmosphere, nor in the interior of the earth. In the greatest depths of the ocean, life, if present, is not plentiful; but it increases in abundance and variety toward the upper portions of the seas.

Plants and animals depend upon air and water, and usually also upon the solid part of the earth for their existence. It is clear that where the spheres come into the most intimate relationship we find the zone of biological activity. There all kinds

of organisms find optimum conditions for existence, sustenance, and reproduction Therefore, any study which concerns itself in a large degree with biological activities must recognize the significance of the interplay of these spheres, and must give attention to some of their outstanding features.

The atmosphere —The atmosphere envelops the lithosphere and the hydrosphere, but it is just as truly an integral part of the planet as is rock or water. That the atmosphere is a substance is readily understood if we bear in mind that it can be weighed and measured like any other matter This is of economic importance. Because of it, air in motion, or wind, may be utilized as a source of power in propelling ships or in turning windmills. Air in excessive motion, as in hurricanes or tornadoes, may be one of the most destructive forces known to man

The pressure of the atmosphere at sea level is 14.7 pounds per square inch, capable of sustaining a column of water approximately 33 feet high or of mercury about 30 inches high This is the basis for the popular expression that atmospheric pressure at sea level is normally 30 inches Pressures above and below that point are referred to as "high" or "low" respectively.

The thickness of the atmosphere is not known, but the evidence of the Aurora Borealis and of meteors indicates that some air exists more than 200 miles above sea level. Whatever the height to which the atmosphere may extend, the barometer proves that one-half of the air, by weight, lies between sea level and 3.2 miles above. Most of the air, therefore, occurs relatively near the rock and water spheres of the earth. The mass, or weight, of atmosphere is estimated to be about 1/1,200,000 of the mass of the solid earth and 1/270 of that of the water. Man lives and moves near the bottom of this atmospheric ocean, whose presence is so unobtrusive that he forgets its existence unless some extraordinary occasion arises to remind him of it.

The hydrosphere.—The hydrosphere, or water sphere, exists for the most part in the depressions of the rock sphere, but because of its penetrative qualities, some water is found in the

pore spaces of the rock, and much exists in the lower atmosphere in the form of water vapor. The great bulk of the water on the earth forms the oceans, which cover about 72 per cent of the surface. The average depth of the ocean is estimated to be about two miles. The greatest depth occurs near the Ladrone Islands in the Pacific, where soundings of 35,400 feet have been made In the Atlantic Ocean the maximum depth so far discovered is in the Nares Deep, a short distance north of Porto Rico, where soundings of 27,972 feet have been made.

The waters in the air and in the ground are both vital to plant and animal life. Ground water not only furnishes the solutions of minerals necessary for plant food, but it also furnishes the liquids for circulation among and through plant tissues. The air serves as the distributing agent for moisture in gaseous form, and through the precipitation of such moisture, ground water is replenished. This interpenetration of hydrosphere, atmosphere, and lithosphere is, therefore, absolutely vital to the continued existence of plant and animal life.

The zones of maximum plant and animal activity exist where bodies of water are in contact with the solid part of the earth. In the shallow waters bordering the continents, the most favorable conditions for marine life are found, and there the fish population reaches its maximum abundance. Prominent examples of such favorable conditions are the Grand Banks off the coast of New England and the shallow waters of the North Sea, each the center of a great fishing industry.

The lithosphere -- The lithosphere, or rock sphere, is the solid part of the earth. Its surface is characterized by great corrugations; the extensive higher portions are known as continental platforms, and the extensive lower-lying portions as ocean basins. The latter give rise to the oceans, and because the waters on the earth are so abundant that they more than fill these basins, there are strips bordering practically every continent where the waters are relatively shallow; these strips are referred to as *epicontinental* seas. The epicontinental seas may be thought of as the areas where the overflow from the oceanic basins covers the lower margins of the continental plat-

forms There is so much oceanic water on earth that the basins proper are too small to contain it.

Maps.—Ever since the dawn of intelligence, man has felt the need of showing graphically the important land and water forms of the area wherein he lived Among the earliest writings known have been found pictorial charts designed to show locations of places described or discussed Crude and simple though they be, they are illustrations of man's attempts at map making Later, as explorations became more carefully recorded and locations more accurately established, higher grade maps were made Interesting maps have been found among old Egyptian papyri and among Babylonian ruins The Greeks and Romans left many maps which give us quite reliable pictures of the parts of the world known in their times.

That the map idea is of universal appeal is shown in its use by primitive peoples The natives of Polynesia construct maps of extensive areas out of palm leaves, showing islands in their respective locations by means of shells attached to the framework The Eskimos of North America and the Yukaghirs of northeastern Asia make maps on birch bark. The nomads at the edge of the desert still draw sketches in the sand to illustrate the routes of their wanderings.

Maps deserve to be ranked among the most important inventions of man. In what other way can we picture readily the many earth features in their proper locations? How else can we visualize the size and form of the country or state in which we live? By means of maps we can visualize location, form, and size of land areas large or small, and furthermore we can show in understandable graphic forms almost innumerable geographic facts. In school atlases are found maps of many kinds, such as physical, climatic, economic, industrial, commercial, and historical, as well as maps showing soils, vegetation, races of people, languages, and religions Students of economic geography will readily see that maps are essential in their study of the distribution of natural resources, industrial products, and commerce.

The earth is most accurately represented by a globe. Such

a miniature replica avoids distortion of the major earth features. Inasmuch as globes are bulky and not practical for use in books or atlases, the need for some means of representing the earth, or parts of it, on a plane surface is an imperative one This raises an important problem; namely, how to represent the surface of a sphere or a portion of it on a flat surface without serious distortion of size or form. A sphere, or even part of a spherical surface, cannot be made into a flat surface without some distortion This will become apparent if one attempts to flatten out even a small part of a deflated rubber toy balloon. It has therefore become necessary to devise methods whereby the earth's surface can be portrayed with as near approximation to the truth as possible.

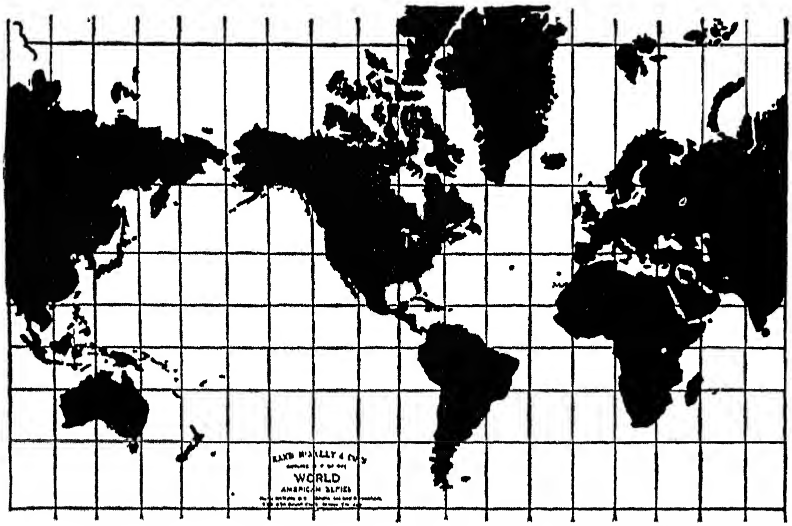
All maps represent areas in more or less distorted form. The larger the part of the earth portrayed by the maps, the greater, of course, are the distortions. If only a very small part of the surface is portrayed—for example, an urban settlement or a township—the actual distortions are so small as to be negligible

In making a map, geographers must contend with the mathematical difficulty of representing the curved surface of the earth, or any portion of it, on a plane surface. As a matter of fact no map, however carefully it may be drawn, can at the same time represent accurately both form and size of an area. Since maps are made to serve specific needs, methods have been devised whereby faithful representation of the particular features desired is achieved, but this usually entails sacrifice of accuracy in other features. Thus different map projections have been developed, each with specific advantages and disadvantages.

Mercator's projection.—The grid of any map projection is obtained by projecting the parallels and meridians upon a flat surface tangent to the globe For example, in Mercator's projection we may imagine a huge cylinder placed over the globe tangent at the equator, and the map projected from the center of the globe. In this projection all the meridians are drawn as straight north-south lines, and the parallels as straight east-

west lines. While on the globe the meridians all converge to common points at the poles, in Mercator's projection the distance between two meridians is the same at the poles as at the equator. To compensate for this distortion of distances between meridians, the parallels are drawn so that the distances between them increase correspondingly toward the poles.

Since parallels and meridians are straight lines on Mercator's projection, distances are also For this reason the navigator finds the projection convenient to establish his course. He needs



Adapted from map of Rand McNally & Co

Fig. 21.—Mercator's projection of the World.

but to draw a straight line from his location to his destination, measure the angle which this line makes with a parallel or meridian, and steer the course accordingly Although such a course is not the shortest route it has the advantage that the sailor can maintain the same bearings

However satisfactorily Mercator's projection represents directions it is poorly suited for representing areas of land masses, especially those located in the higher latitudes On this projection Greenland appears as large as Africa, whereas it is really only about one-thirteenth as large This excessive distortion

is readily understood if one bears in mind that Mercator's projection makes the poles, which are really points, into lines as extensive as the equator, and that parallels are spaced farther and farther apart toward the higher latitudes in the same ratio that distances between meridians are exaggerated. On wall maps used for instructional purposes, the use of this projection should be discouraged.

The conic projection.—The conic projection is far better suited to represent the land masses of the world than is Mercator's projection. In drawing the conic projection use is made of the fact that part of a sphere is quite similar to part of a cone. If we can imagine a huge cone placed over the earth, and parallels and meridians drawn on it from the center of the globe, the resulting grid, when the cone is unrolled, would closely approximate the parallels and meridians on the globe itself within a belt not too far removed from the parallel of tangency. The meridians appear as straight lines radiating from the pole and the parallels are represented by concentric arcs about the pole as a center. (Figure 22.)

The especial virtue of the conic projection is that small areas may be represented with relative fidelity. In the figure, the part of the cone nearest the parallel of 30° corresponds to the area of the globe. East-west distances along the parallel of tangency are represented accurately. An area mapped within a strip nearly tangent to the sphere will show little distortion in latitude. Distortion increases northward and southward from this strip. The flaring edge of the cone stretches the map in all directions, thus causing increasing distortion of form and area with increasing distance from the parallel of tangency. Consequently, the conic projection is best suited to show areas that have considerable east-west extent. For this reason, it is often used in making maps of Europe, and particularly of the Mediterranean lands. Generally speaking, the conic projection is also well adapted to show small areas.

Polyconic projection.—In the discussion of the conic projection it was stated that distortion increases northward and southward of the zone of tangency. To remedy this difficulty

and make all of the sphere approximately tangent to the cone, the polyconic projection has been devised. Polyconic means "many cones." If, instead of a single cone placed tangent along some parallel on the globe, we picture a series of superimposed cones, each tangent at a different latitude, we can

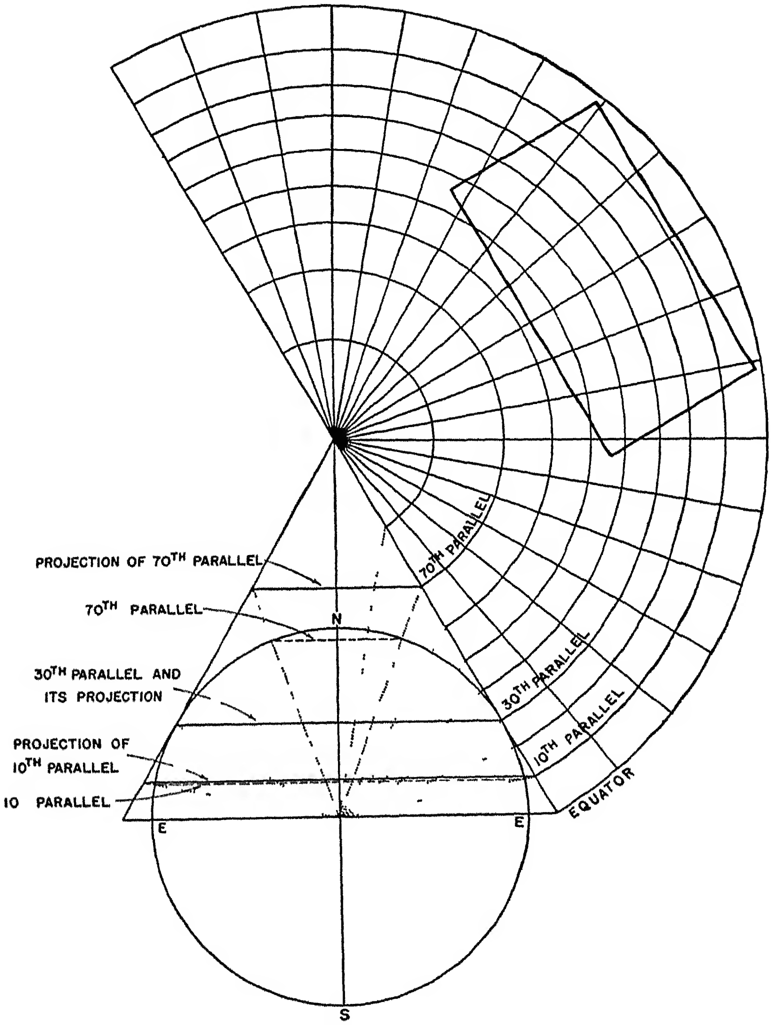


Fig. 22.—Central conic projection. The rectangle shows the type of map grid obtained by using this projection Especially suitable for small areas and for regions which have relatively large longitudinal extent.

understand the idea of the polyconic projection Since distances at each line of tangency are correctly represented, and the distortion near each such line is only slight, it is possible by this projection to construct a map of greater accuracy than on the simple conic projection On the polyconic projection the meridians curve toward the poles and the parallels spread somewhat toward the margins, thus giving to the map an appearance of bulging. The Polyconic is preferred for showing large areas, particularly those with great north-south extent; as, for example, Africa, North America, or South America.

The Mollweide homolographic projection--None of the

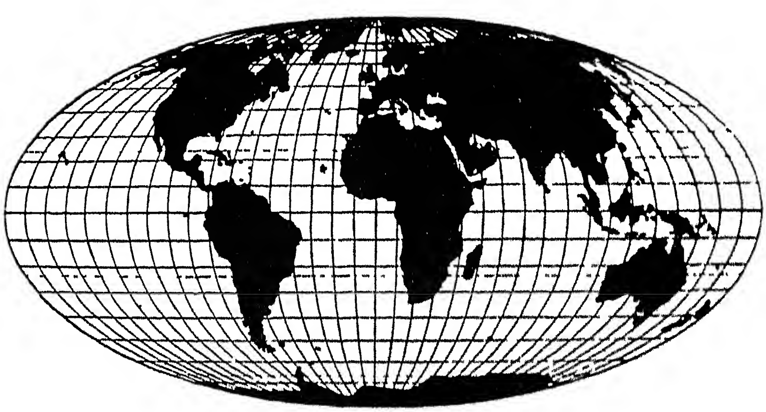


Fig. 23.—Mollweide's homolographic projection of the World. (From Huntington and Carlson: *The Geographic Basis of Society*, New York, 1933. Prepared by F A Carlson.)

three projections named above is suitable for representation of the entire globe on one map. Homolographic projections get their name from the fact that they are equal area projections. On them any given quadrangle bounded by two parallels and two meridians is equal in area to any other quadrangle similarly bounded The Mollweide projection, named after its inventor, is extensively used because it avoids distortion of areas. It involves, however, distortion of directions, particularly near the borders of the map grid. This is in contrast to Mercator's Projection, which does not distort direction but distorts areas.

On the Mollweide projection all parallels are drawn as

straight lines. The mid-meridian is also drawn as a straight line, but the other meridians become more and more curved, particularly towards the poles.

Goode's interrupted homolographic projection—the homolosine.—The homolosine is a modification of the Mollweide projection. The late Professor J. Paul Goode conceived the idea of centering the larger continents on meridians which may reach from pole to pole or merely from pole to equator The spacial interruptions which occur on his projection allow a faithful representation of the shape either of the land masses or of the oceans in the higher latitudes On the other hand these

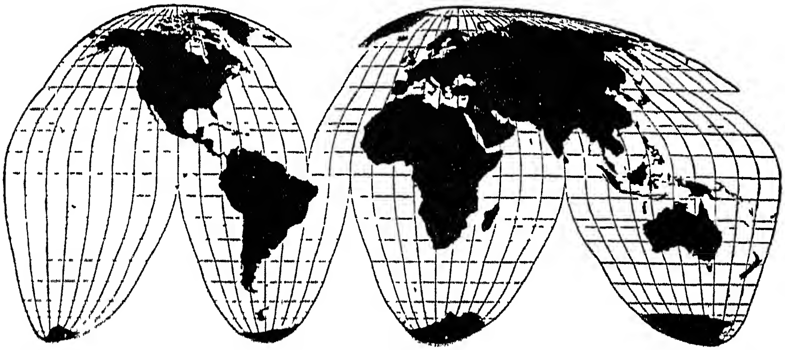


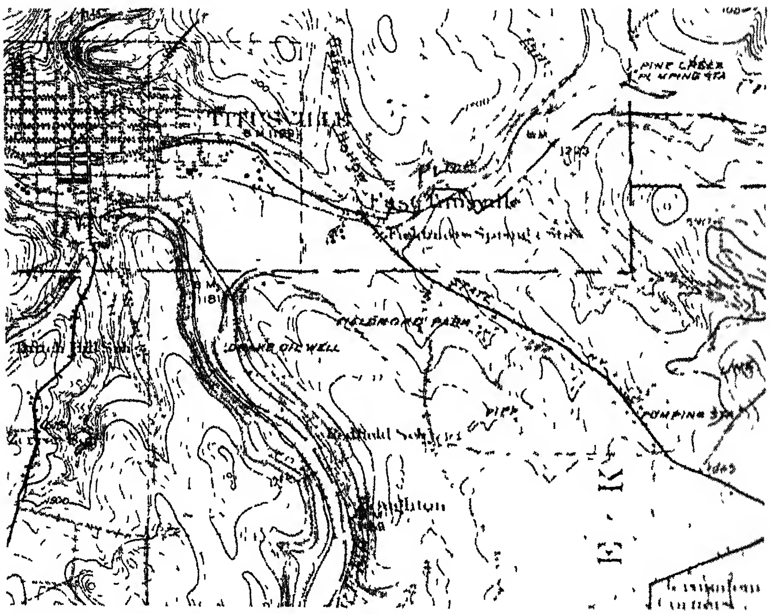
Fig. 24. Goode's interrupted homolosine projection. (Goode Series of base maps and graphs, by permission of University of Chicago Press)

interruptions are objectionable in maps to be used for certain purposes; as, for instance, those illustrating world trade.

The scale.—All maps are necessarily smaller than the actual surface areas which they represent. To interpret correctly distances on them it is essential to know what relation exists between a certain linear distance in the field, and the same distance on the map. This relation is called the *scale* of the map For example, if the distance between two houses is one mile, or 63,360 inches, and on the map the symbols for these houses are one inch apart, then the scale of the map is 1/63,360 or 1·63,360. The metric system, with its simple relationships between units of measurement, gives the most satisfactory map scales. If the distance between two crossroads is 10 kilometers

(a little over six miles), or 1,000,000 centimeters, and this distance is represented on the map by one centimeter, then the scale of the map is 1:1,000,000.

If the ratio which expresses the scale of a map is a small value, as 1.10,000,000, we speak of it as a small scale map. If it is large—e.g , 1 2,500—we speak of it as a large scale map. Large scale maps show relatively small areas of the earth's surface. Small scale maps, on the other hand, may show whole



From Titusville Quadrangle, U S Topographic and Geologic Survey, Washington, D. C., [illegible]

Fig. 25 —Section of topographic map near Titusville, Pennsylvania.

continents, or even the entire earth The former can show much detail, the latter can show only the major features of the area represented Most maps in atlases are small scale maps of continents, parts of continents, countries, etc. Such maps are useful for reference purposes, and to convey a general idea of the major features of the natural and cultural landscapes.

For practical purposes large scale maps giving considerable

detail are necessary. Of these, topographic maps are perhaps the most important. They are usually made and published by the governments of the various countries. Their scale rarely is smaller than 1:250,000. The uses of such maps are legion; in fact, no civilized country can do without a set of large scale maps, covering at least all the important sections of the country. Topographic maps give much useful detail about differences in elevation, types of surface, distances, facts of human occupation, and so on. They are useful for military purposes, and they form a necessary basis for detailed geological and soil maps, for the planning of roads, for irrigation and drainage works, and for the solution of many other practical problems. In some countries they are in great demand by tourists. The topographic maps of the United States are published by the Geological Survey at Washington, D. C., and usually they are on a scale of 1:62,500 or 1:125,000.

Land survey maps in the United States.—Maps showing the exact location of real estate, also among the most important large scale maps, are of prime necessity to organized society. Private ownership would not be possible without the location and delimitation which such devices provide. Such maps are equally important in the assessment of property, in the securing of land mortgages, or in any other transaction in which real estate is involved. The significance of such transactions in the business world should induce all citizens to familiarize themselves with the principles involved in accurate description and representation of the location of definite parcels of land.

Metes and bounds.—The early pioneers brought with them the old European system of location by metes and bounds. To locate an area by this method, landmarks such as trees, streams, rocks, highways, and stakes are selected as points of beginning. Directions are then determined by the magnetic compass, and distances are ascertained by surveyors' chains. These landmarks, however, are not permanent, and even magnetic north is slowly but continually shifting. The confusion and uncertainty associated with this method of land survey early led to dissatisfaction, but any change is difficult when

land ownership has once become established under it. That is the reason for the continuance of the metes and bounds system in the older sections along the Atlantic Coast even now. When the new lands west of the Appalachians were acquired as part of the national domain, improved methods of land description were sought and later adopted.

Acts of Congress in 1785, 1796, 1800, and 1805 provided the groundwork for a completely new and more orderly method

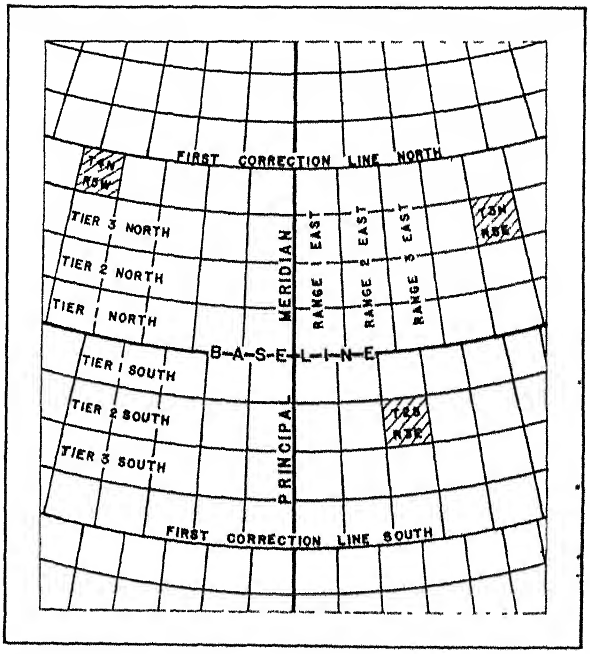


Fig. 26.—Diagram of principal meridian, baseline, townships, and ranges.

of surveying for the newer territory to the west. Location on spherical surfaces necessitates a carefully established intersection of a meridian and a parallel as a starting point. Since it was not practical to refer all surveys to the same meridian and the same parallel, several were determined and designated as the reference lines for civil land survey districts. These were designated as Principal Meridians and Base Lines, respectively.

Principal meridians.—Principal meridians are run north or south, or both, from some initial point which is accurately located by latitude and longitude. About thirty-two of these principal meridians of varying length have been surveyed at convenient intervals The first meridian of this nature serves as the boundary line between Indiana and Ohio The second is west of the center of Indiana. Some of the principal meridians are known by name, others by numbers The one bisecting the eastern part of Nebraska, for instance, is known as the sixth principal meridian The Tallahassee principal meridian, on the other hand, runs through the city of that name, and is only 23 miles long North and south strips of land about six miles wide, called *ranges*, are laid off to the east and west of these meridians and are numbered consecutively Each principal meridian, with its system of ranges, is independent of other like systems.

Base lines, extending east and west, are run through the initial points on the principal meridians At distances of six miles and multiples thereof from the base line, parallel lines are drawn, forming what is known as tiers of townships. These are numbered consecutively north or south from the base line.

It will be noticed on the illustration (Fig. 26) that 24 miles north of the base line slight jogs occur east of the principal meridian, to the right, whereas west of it the jogs occur to the left. Although the delimiting meridians are separated by intervals of six miles on the base line, the sphericity of the earth causes them to converge northward. At latitude 40° the convergence is about 6 7 feet per mile, which amounts to more than 40 feet for each township. In order to provide for townships of about equal area these jogs, known as *correction lines,* are usually arranged at intervals of 24 miles The enclosed units of land, approximately 36 square miles in each, are known as "congressional townships" as distinguished from the political subdivisions of the county called "civil townships"

In this scheme of land survey, a square mile is known as a section. The usual manner in which sections are numbered and identified is illustrated in Figure 27.

The subdivision of sections is computed by halves, quarters, and half-quarters. A number of ways in which a section may be subdivided are illustrated by Figure 28. The divisions are really simpler than they appear at first glance. The essential fact is that a section of land embraces 640 acres, and that portions are designated as definite fractions of this number. Thus if the description reads S ½ NE ¼ sec. 20, the area is 80 acres;

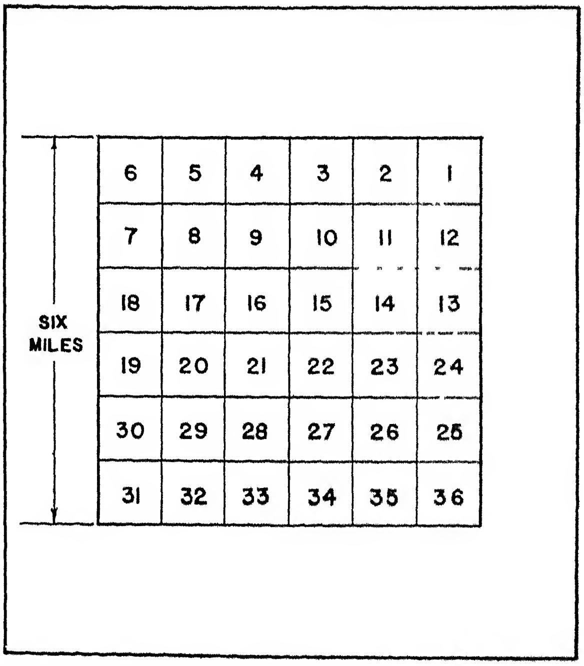


Fig. 27.—Diagram showing scheme of numbering sections in a township.

if a description reads NW ¼ SW ¼, only 40 acres are included.

Summary.—In this chapter a generalized overview of "Our Earth" has been presented. Intelligent people are expected to know something of its size, motions, and relationships to the sun and the solar system. An appreciation of the significance of insolation and the sequence of seasons, both as to causes and consequences, is fundamental to an understanding of human activities. The earth must be thought of in all its phases as

involving air, water, and rock spheres, as well as distribution of land and sea. And finally, maps are the tools by means of which we describe and visualize the surface of areas and the distribution of people, activities, and resources. All these aspects are vital in developing an ability to study intelligently the industrial and social problems of the times

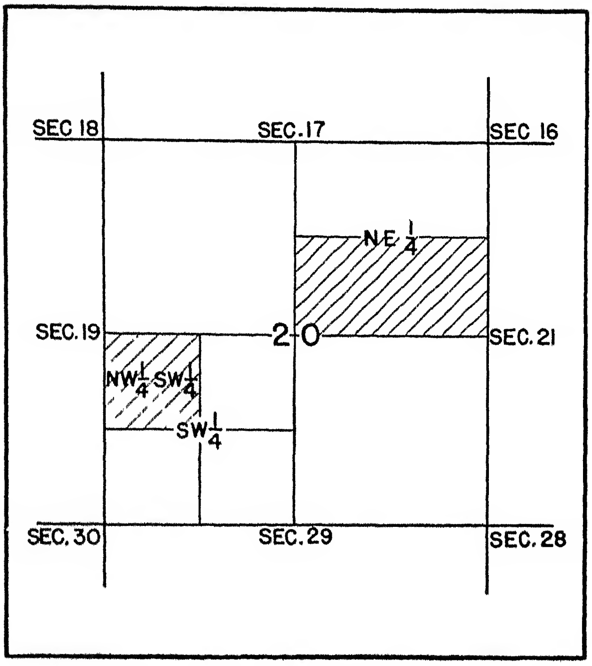


Fig. 28. Diagram of mode of subdivision of a section.

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CHAPTER IV

Interrelationships of Environment and Human Needs and Activities

WHEREVER man is, he must play his part if he would survive. His needs and his activities vary with the conditions which surround him. Within certain limits he must adjust his manner of life to his environment. The plateau dweller of Bolivia is confronted with problems quite unlike those which the inhabitant of the Amazon lowland must face. He must cope with cold, drought, and scarcity of timber, whereas in the Amazon lowland all-year warmth, copious rainfall, and dense forests are the impressive aspects of the environment. Similar differences in various parts of the world can be enumerated by the score, for example, the nomad of the desert and the tree dweller of the jungle; the wheat farmer of northern China and the rice farmer of the southern part, the fisherman of New England and the coal miner of West Virginia; the cotton planter of Mississippi and the oil producer of Texas; the lumberman of Washington and the ranchman of Montana. In each case environment bears a direct relationship to human activities, and these in turn lead to distinctive social and economic results.

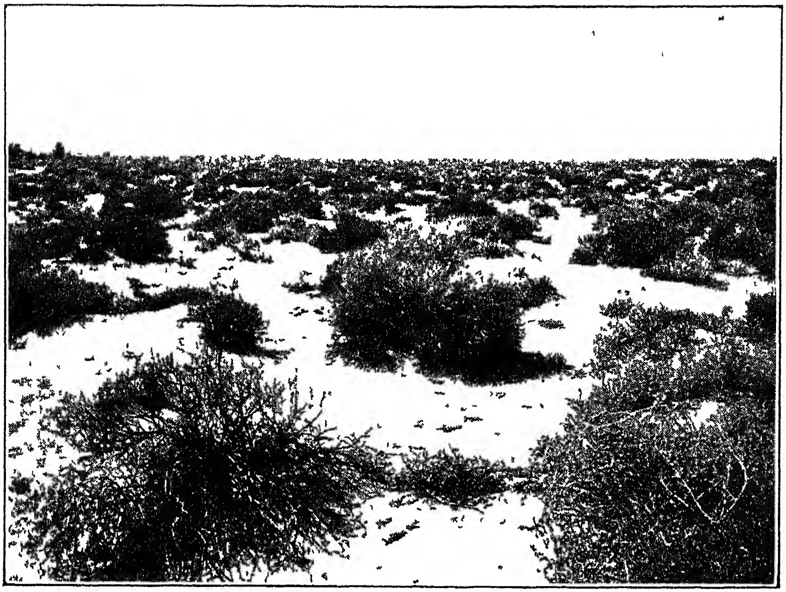
Illustrations of contrasts can be multiplied almost without end. At first thought they seem to present such a diversity of conditions and responses that the task of mastering an appreciation of them appears hopeless. Nevertheless, if we view systematically this medley of factors and results, we shall find that they may be listed under relatively few headings, and thus they can be treated in a rational, scientific manner. Systematic treatment enables us to view the unlike elements of causes

and consequences as an orderly whole rather than as a mysterious maze.

Relationship of natural landscape to the cultural landscape.—The factual content of geography consists of two major groups The first of these may be thought of as the *facts of the natural environment*, the second as the *facts of man's activities* Location, climate, land forms, soil, minerals, vegetation, and animal life are generally recognized as the principal factors of the natural environment These constitute the physical and biological world By man's activities we refer to his various occupations, such as farming, mining, manufacturing, hunting, the trades, and so on. Through his activities, man develops within a natural environment a system or series of institutions which are usually termed his social environment.

The natural environment in any given area is usually well reflected in the features of the *natural landscape*. By that term we refer to the land as it is with its various kinds of surface forms, its streams and lakes, its natural vegetation, and its native fauna. Through man's activities, changes are brought about, such as plowing up the sod, cutting down the forests, planting various crops, straightening or deepening stream channels, constructing irrigation projects, and preparing grades for roads and railroads. In these and in other ways the natural landscape is changed in its details and rendered more adaptable for use by man. By these means a *cultural landscape* is created. This cultural landscape is superimposed upon the natural landscape, and thus, in most instances, the environment in which we live embraces both of these major phases. Our work is to correlate these groups of facts, namely, those which deal with the natural environment on the one hand and those which deal with man's activities and his institutions on the other. Through such correlation we expect to discover the relationships which exist between the two, and particularly to determine the light which the natural environment sheds upon what man does.

In order to understand relationships, one must have a mastery of the essential facts involved, a mastery which can



Courtesy, United States Bureau of Reclamation, Washington, D C

Fig. 29.—Natural landscape in the Lahontan bush-steppe area, Nevada.

Courtesy, United States Bureau of Reclamation, Washington, D C

Fig. 30.—The same region as figure 29, transformed into a cultural landscape with the aid of irrigation. Newlands Project, Nevada. Alfalfa ready for cutting, three year old wind break to the left.

be reached best through definite and systematic organization It is suggested, therefore, that the facts of the natural environment be summarized rather definitely into six major groups, namely, (1) location, (2) climate, (3) land and water forms, (4) land content, or soil and minerals, (5) native vegetation, and (6) native animal life If each of the above topics is adequately treated for any area on earth, the resulting description will present a clear picture of its natural landscape.

Location—a major geographic factor.—Among the elements which make up the natural environment, location is perhaps the most fundamental Regardless of whether areas are large or small, whatever may be true of their land forms, types of climate, soil and mineral resources, native plants and animals, or man's activities, location is important in understanding the occupations. Location in itself, regardless of all else, is often a foremost factor in the possibilities of the growth of a city or in the success of a business For example, it is clearly recognized that small towns located near large cities rarely grow into important trading centers because of being overshadowed by their greater neighbors. Even in matters of current events, location is always given in the presentation of the story in order that the reader may know where the scene of action is laid. Such information is valuable in interpreting the significance of the event and in understanding its causes and consequences. Location, therefore, should be carefully stated in connection with every geographic description, and in most cases it is equally important in economic reports on business enterprises

Elements of climate.—The significance of climate is always apparent. People build their homes in response to climatic conditions; they dress largely as the weather dictates. The crops which man produces are almost entirely a response to temperature, rain, and wind. The principal elements of climate with which one should become familiar are rainfall, temperature, humidity, and winds

The distinguishing characteristics of the rainfall of any locality can be summarized in terms of its average annual

amount, seasonal distribution, variability, and presence or absence of snow. The annual amount of rainfall is usually stated in inches or centimeters, and is popularly referred to as light, moderate, or heavy In actual practice we think of any rainfall below 20 inches per year as being light, that from 20 to 40 inches per year as moderate, and above 40 inches as heavy. Seasonal distribution is referred to with emphasis upon winter

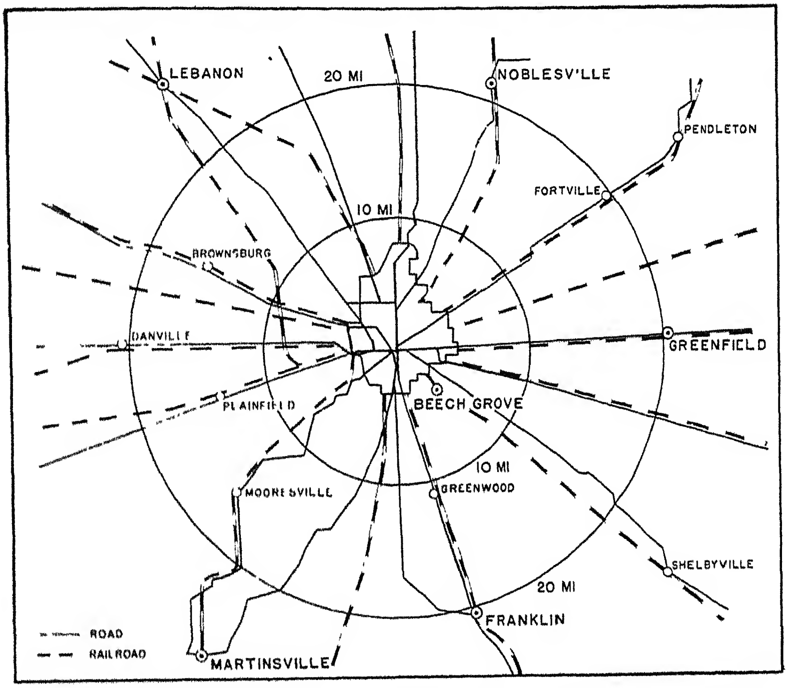


Fig. 31. Map of roads and railroads centering upon Indianapolis, Indiana. The attraction of a large city precludes the growth of minor towns within a considerable radius.

or summer conditions, because in many cases the distribution of rainfall is fully as important as the amount For example, the agriculture of the Mediterranean lands is based on crops which mature early because there summer is characterized by little rain, whereas in the Corn Belt of the United States agriculture is organized on a basis of summer rains and winter drought. Where the frostless season is five months' duration

or longer, and sunshine is abundant, summer rainfall is conducive to corn as a crop, whereas summer drought prevents successful corn production except under irrigation; as a consequence the Corn Belt of the United States extends from Ohio to Nebraska, in the area of summer rains, while in Spain and Italy, where summer drought is characteristic, early maturing wheat is produced.

The type of rainfall often determines its usefulness. For example, gentle rains soak into the ground and thus are much more effective in promoting plant growth than are torrential rains. The latter not only give rise to a lower percentage of soak-in, but also cause heavy run-off and resultant soil wash. A smaller amount of rain falling gently is, therefore, more efficient in furthering agricultural activity than is a heavier rainfall of torrential type.

Variability of rainfall is another important factor. In many areas the amount of rainfall may be twice as great one year as another This is often true within the tropical climates, where in one year the rainfall may be as high as 140 inches and the following year drop to 70 or 80 inches. On a percentage basis, however, the variability is no greater there than in many of the semi-arid areas of the world where 30 inches may fall in one year, followed by a year wherein the total may drop to less than 15 inches. Great variability, wherever it occurs, whether in regions of heavy or light rainfall, gives rise to difficult problems of agricultural adjustment

Temperature involves day to day and day to night changes as well as the frequency and severity of frost and the length of the frost-free or growing period Highest and lowest temperatures in given cases are fully as important as average seasonal or annual temperatures. In the study of any area, one should give special attention to the known maximum and minimum temperatures and to the length of the frost-free season. In general, the middle latitudes are characterized by large differences between cold-season and warm-season temperatures, whereas in the high and also in the low latitudes the differences in seasonal temperatures are relatively slight. Hence in this

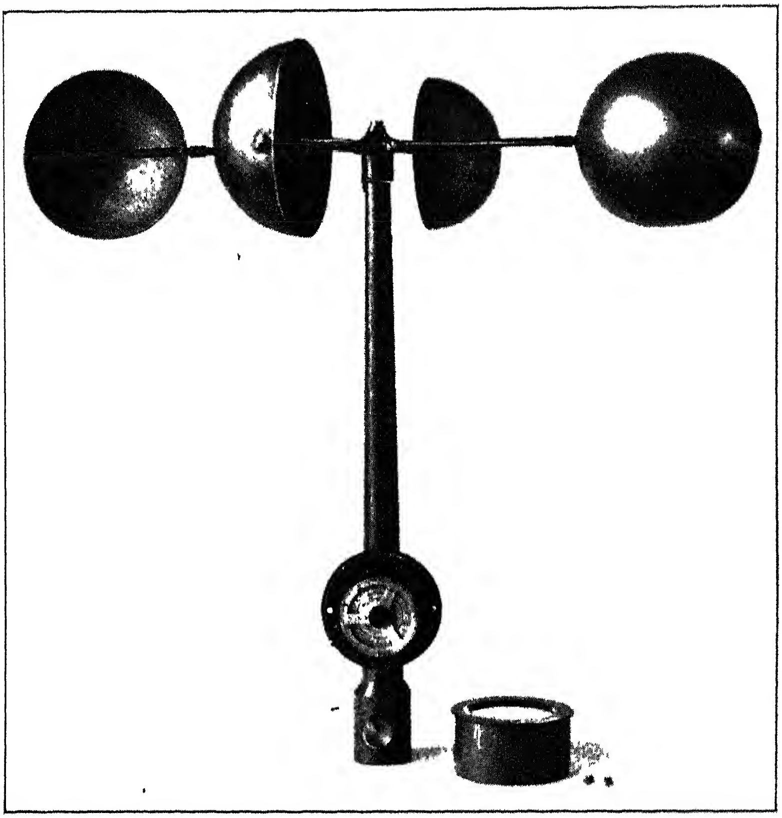
regard the so-called temperate climatic belts are the most intemperate.

Humidity is one of the principal elements of climate It is often referred to as the condition of the atmosphere with respect to its content of water vapor, a statement which, if strictly interpreted, is somewhat at variance with the truth Humidity refers to the water vapor in the space near the earth, not to the water in the air. Relative humidity is the actual amount of of water vapor in a unit volume of space compared with what could be held in that space at the same temperature without condensation. When we speak of the air as being humid, or refer to the high humidity at any given time, we mean that there is a relatively high percentage of water vapor present in the space which is occupied also by the air.

The point of saturation, known as the dewpoint, is reached when any volume of air contains as much water vapor as can exist there without condensation The capacity for containing water vapor increases with temperature, and at a rate somewhat greater than a direct ratio That is, if the temperature in a given space doubles, the water vapor holding capacity is more than doubled For this reason the relative humidity is usually greater in cold weather than in warm weather even though the absolute humidity, or actual weight of water vapor in a given volume of the air, may be much less. The effect of this condition is readily understood when we contrast the rapid drying characteristic of warm, "sunshiny" days with the slow drying which is so characteristic of cold days. For example, in the summer time roads and fields dry up quickly after a rain, but in late autumn or in early spring even small rains give rise to a muddy condition which lasts a long time. Humidity is an important factor of climate and is, therefore, carefully measured by an instrument known as a *hygrometer* and recorded by the principal weather bureau stations in various countries Records of humidity refer to it in terms of percentages, as 40, 70, 90, and so on, in each case the saturation point being 100

The fourth prominent climatic factor is that of wind. Wind may be defined as air in horizontal motion near the surface of

the earth Air in motion high above the surface is ordinarily spoken of as air *currents* rather than as winds The velocity of the wind is expressed in miles per hour and is measured by a device known as the *anemometer*. In ordinary accounts of wind velocity we are, however, much more likely to find it referred



Courtesy, United States Weather Bureau, Washington, D. C.

Fig. 32 - Anemometer, for measuring wind velocity. The horizontal movement of the cups turns a vertical shaft, the speed of movement thus registering below.

to in approximate terms, such as calms, light, moderate, or strong winds, and storms or gales. The variability and seasonal distribution of winds as to intensity and direction are of great importance. In some areas winds blow steadily from one prevailing direction during most of the year, whereas in other lo-

calities winds blow from one direction in one season of the year and from other directions in other seasons In the large continental land masses the prevalent summer winds may be just opposite in direction from the prevalent winter winds Inasmuch as the winds are among the most important features of the climate which impress themselves daily upon life, they should always be adequately described and intelligently interpreted.

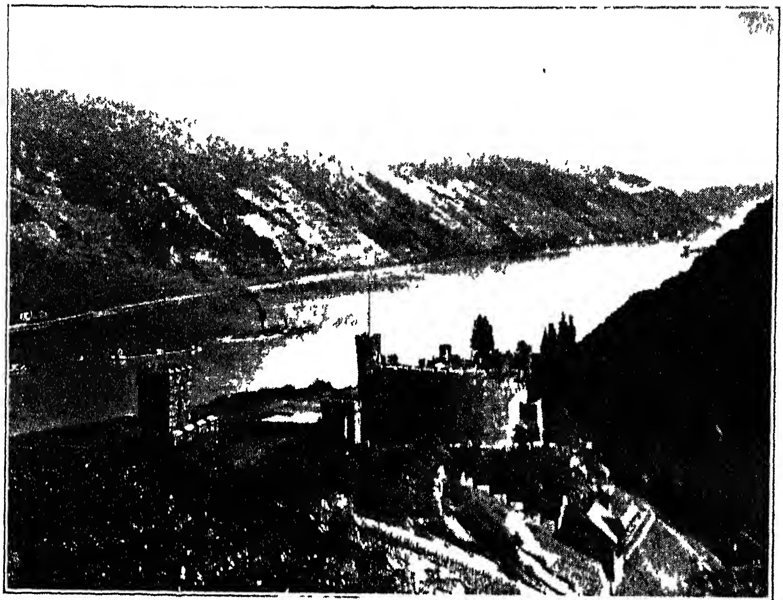
Major land forms.—*Topography* implies description or representation of the surface of the land, whereas the unevenness of the land surface is spoken of as the *relief*. In a technical description, relief is stated in feet or meters; that is, the difference between the altitudes of the high areas and those of the low areas Relief is thus presented in exact quantitative terms In most of the general descriptions of the land we find its topography described under four major divisions, namely, mountains, plateaus, hilly lands, and plains, terms that are in almost universal use While they do not lend themselves to scientific detail, for ordinary purposes they define the character of the land surface in an effective manner. They are terms which people everywhere use when describing the land of any given area, and this usage justifies geographic recognition.

Water bodies as a factor in environment.—That bodies of water are important environmental features is evident to all What small boy in country districts has not felt the spell of the water hole, or has not experienced the thrill of catching diminutive members of the finny tribe which later, as the stories were re-told, took on greater and greater proportions?

The indirect influence of water bodies pervades all land areas of the earth. The water which falls as rain must have come from the sea, whence it rose as water vapor and made the voyage from source to destination in a gaseous state. Water bodies modify temperatures over sea and land, in greatest measure of course along coastal areas, but in some degree also in the very hearts of the continental land masses. In addition to the effects of large water bodies upon the climate, there are important geographic relationships to transportation and industry.

Ocean-borne commerce makes the whole world kin. Through it we are enabled to sell our goods in all parts of the world and in turn to enjoy the products of distant lands in our own scheme of living.

The influence of water bodies as a feature of our environment is not limited to the great seas and oceans. The small lakes which are peppered over the land in many areas, and the net-works of streams which cover the land nearly everywhere, are



Courtesy, German Tourist Information Office, New York City.

Fig. 33.—Water transportation on the Rhine River. Tug boats and barges ascending the river, in the famous Rhine Gorge, near Bingen.

directly effective in every community. As water supplies, as power resources, as drainage channels, or as transportation routes, they are of economic significance to every community. Furthermore, the lakes, ponds, and streams furnish facilities for fishing, boating, canoeing, skating, and other recreational activities which represent social assets equalling or surpassing their economic values.

Geographic significance of the content of the land.—The content of the land should be thought of as consisting of two

major groups; namely, mineral deposits and soil material. This content is responsible for the human activities in many regions of the world In some districts the principal productive occupation of man is that of extracting mineral wealth by means of mines, quarries, and oil wells This type of activity is referred to in the aggregate as *extractive*, in that it takes out of the land something which is not replaced, and therefore leads to eventual exhaustion. The great power fuels—coal, petroleum, and natural gas—are representative of this type of industrial activity.

Soil material and soil are so important and so universally distributed that they merit more extended discussion than is usually presented in geographic descriptions Without indulging in technicalities which would be justifiable only in a treatise on soil science, the geographer must refer to some essential qualities of the soil if his descriptions are to be sound and significant. Among the qualities of the soil most commonly recognized and discussed are color, texture, structure, thickness, and the presence or absence of hard layers, known as hard pan, near the surface.

The color of a soil depends upon its mineral and organic content. In general, brown and reddish soils owe their color to the presence of *iron oxides*, of which ordinary iron rust is the most common example. Dark colored soils, approaching black, are usually rich in *carbon*, generally referred to as organic matter. Color in itself is not proof of fertility, but quite generally people prefer dark colored soils because organic content is essential to vigorous growth of most plant life.

Texture refers to the size of the particles which constitute the soil or any other natural earth substance. If the texture is too coarse, the soil is quite likely to let water pass through too rapidly and thus be drouthy; if too fine, the soil becomes too compact, drains too slowly, and is difficult to cultivate successfully. Soils which are medium textured tend to absorb and retain moisture, are readily tilled, and hence give rise to favorable agricultural conditions.

By *structure* we mean the arrangement of the soil particles

within the mass Studies during recent years have revealed this as a most important property in accounting for soil differences. It involves factors too complex for detailed treatment here, but in a simple way we may think of soil particles as being arranged in thin layers or plates, rough cubes, small columns, irregular granules, or as having no arrangement at all. The water-holding capacity of the soil, its adaptability to cultivation, and even its productive capacity are, in most cases, directly related to its structure.

Not all earth materials are soil Generally speaking, only the highly weathered, plant-utilizing earth material at the surface may be termed soil. Below it lies the partly altered parent material known as subsoil. The thicknesses of the soil and subsoil vary greatly, and in some places the surface soil is subject to such rapid wash and erosion that no true soil zone ever develops.

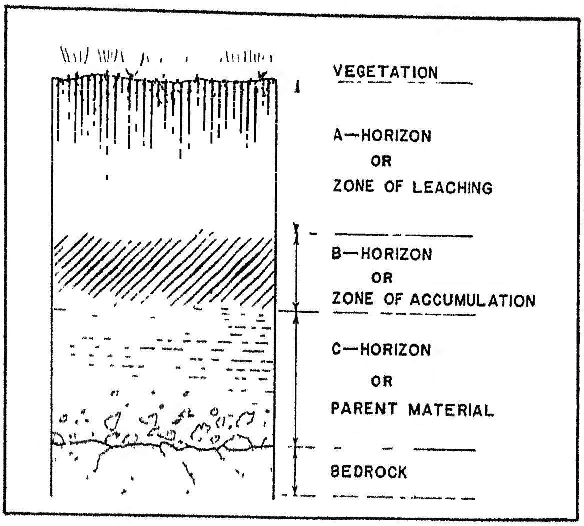
In vertical section, we usually recognize three more or less distinct layers commonly referred to as the "A," "B," and "C" horizons Near the surface, plant and bacterial action tend to incorporate humus with the soil. In a period of time the upper layers become so changed that they bear but slight resemblance to the original materials. This highly altered zone is commonly termed the "A" horizon. It is best developed, as to quality and depth, in the soils of the temperate climatic belts in which the rainfall is moderate.[1]

Below the "A" horizon is usually a layer, termed the "B" horizon, of varying thickness wherein only partial alteration of parent material has occurred. There, however, some properties have developed which differ from both the overlying and underlying zones. There may be differences in texture, color, compactness, or content which give rise to a well defined layer related to the parent material yet differing from it and bearing similar relationships to the overlying more completely altered layer The "B" horizon is commonly termed the subsoil.

Underneath the "B" horizon is the unaltered parent material,

[1] Rainfall of about 25 to 40 inches

termed the "C" horizon. In popular language people often say that the subsoil extends to bedrock Where the mantle rock is shallow this may be true, but where it is deep, as, for example,



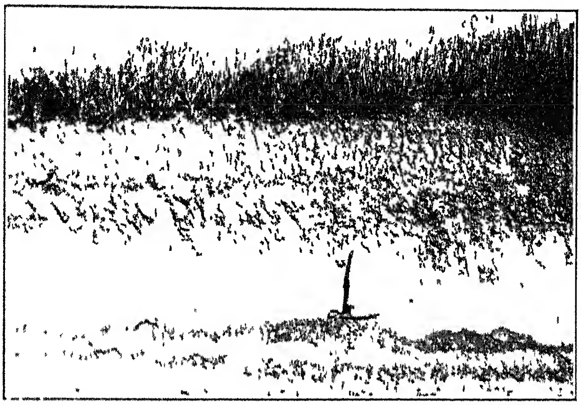


Fig. 34a. -Diagram showing soil horizons.
Fig. 34b Photograph showing shallow soil horizons of a semi-arid region, north of Alliance, Nebraska.

on the extensive alluvial plains or on the loess plains of the Middle West, the lower portion is parent soil material rather than subsoil, and therefore should be referred to as the "C" horizon.

Native vegetation.—Native vegetation refers to the natural plant growth which mantles the earth's surface. In some places the native vegetation is quite simple, as for example in parts of the southern pine forests, where large areas are made up of only a few species of plants. In other places it is exceedingly complex, as for instance in the low latitude jungles and in certain sections of the Great Plains. If we consider the earth as a whole, the native vegetation varies from a few plants of the same species widely scattered over rock wastes to intricate plant associations of great variety well shown in the tropical or equatorial forests Inasmuch as most plants are practically immobile—that is, they cannot move about—they must depend entirely upon their immediate environment. Where a number of varieties are present, such species dominate as are best adapted to the growth and maintenance factors of that locality. These factors are soil, temperature, rainfall, drainage, and sunlight.

The dominance of one or two species of plants in a district is often of economic importance. For example, natural forests consisting wholly or largely of but one or two species are the most valuable, because timber and other forest products are more easily removed where the stands are pure rather than mixed. In the forests of the low latitudes, trees of a single species are usually widely scattered, and within any given area a number of different varieties are intermingled. Such a medley of varieties adds to the cost of lumbering to such an extent that in many places lumber can be imported from higher latitudes more cheaply than it can be made from the timber of nearby forests.

Crop plants cultivated by man are not included under the term native vegetation. Wherever man breaks the sod, cuts the forest, or stirs the soil, and cultivates crops, he creates an artificial landscape. Thus, plantations devoted to rubber, cotton, cacao, or coconuts, and fields planted to corn, wheat, tobacco, or sugar cane are not clothed in native vegetation, but are farmed areas constituting a phase of the cultural landscape.

The vegetation of the earth can be classified broadly into

four principal divisions (1) forest, (2) savanna, (3) grassland, and (4) desert Since the climatic conditions which are responsible for these divisions do not have sharp boundaries, the plant groups are usually not separated by any sharp lines Therefore, it is not possible to define the exact margins of the various divisions or of their subdivisions, but lines are established to mark the places where one ceases to predominate and another becomes dominant

In general, forests occur in regions of heavy to moderate rainfall, grasslands and savannas occur where rainfall is moderate to light, and deserts where the rainfall is scant These generalizations will be found helpful in correlating vegetation with climate in the different parts of the world

Since the native vegetation has such importance, not only as a fundamental economic resource but also as an indicator of possible utilization of the land, we should learn to think of it systematically. The larger divisions and their principal subdivisions can be described in rather simple terms Such descriptions enable us to see more clearly the relationships among the divisions and the environments in which they occur The discussional outline which follows is designed to serve such purpose.

I. **Forest Formations:**

A *Hygrophytic*, moisture loving or moisture tolerant type of forest

1. Broad-leaved evergreen tropical rain forest

   This type is found in the rainy lowlands of low latitudes, as, for example, in the Congo Basin and in the lower Amazon Valley The trees have no periodic leaf fall and the forest is ever clothed with verdure Numerous varieties of trees and mixed stands are the rule

2. Narrow-leaved evergreen rain forest

   While most moisture-loving trees are broad-leaved, there are areas where narrow-leaved species predominate, even under conditions of all-year rain and moderate temperatures. Examples of this type are found in the spruce and fir forests of southern Chile and along the west coast of Washington and British Columbia

B *Mesophytic* tolerant of seasonal drought or cold, or both

1. Broad-leaved evergreen subtropical forests

   In this class are placed the live oaks of southeastern United States and somewhat similar tree groups of the Mediterranean lands. They occur where there is either summer drought or moderate winter cold and consist of species which have developed tolerance of such conditions

2. Broad-leaved deciduous forest in low or middle latitudes

   This type is characterized by periodic leaf fall induced either by drought or by freezing temperatures Wide distribution is characteristic, notable examples being found on every continent Among the best known are the mixed hardwoods of eastern United States, such as the oak-hickory forest or the beech, birch, and maple forest There the leaf fall is induced primarily by the freezing temperatures of approaching winter On the other hand, deciduous broad-leaved forests are found in India, parts of Australia, and along the west coast of Central America where seasonal drought induces leaf fall These are also classed as mesophytic types

3. Narrow-leaved evergreen temperate forest

   This type is of wide extent, embracing a large percentage of the pine and spruce lands of all continents It occurs at moderate to high altitudes in the low latitudes, where elevation causes climatic conditions such as are characteristic of middle latitudes. The most extensive areas, however, are in the middle latitudes, where vast forests of almost solid stands of pine, spruce, or fir occur. Notable examples of this type are the pine forests of southeastern United States, the fir of the northwest, the spruce of Canada, and the several kinds of coniferous forests of Scandinavia and Russia

C *Xerophytic*, tolerant of protracted periods of severe drought

   The desert shrub is the typical form of the xerophytic group Well-known examples are the mesquite and greasewood of the desert and near-desert areas in southwestern Texas, New Mexico, Arizona, and in the Great Basin of Nevada and Utah

II. Savanna Formations·

These include grass stands wherein are found scattered trees or clumps of trees, particularly in the warmer latitudes. Savannas may be considered to be transition zones

between the forests and grasslands of low latitudes, although the term is also used to include some wet grasslands in the middle latitudes where scattered tree growth occurs Perhaps the best-known example of an extensive savanna area is the Sudan of Africa

III. Grassland Formations:

Grassland formations are variously classified, depending upon the point of view from which the classification is made Based on land utilization aspects, grasslands may be divided into the following four major types

A. *All-year pasture type*

This is characteristic of regions of even rainfall distribution throughout the year, little or no snow, and mild temperatures Well-known examples of this type are the islands of the English Channel (Jersey, Guernsey) and the lowlands of Ireland The grasslands of the Puget Sound lowland are also of the same general character

B *Tall grass, summer pasture type*

The areas of tall grass which occur in the middle latitudes are usually called *prairies* Tall grasslands are the response to moderate rainfall, generally above 20 inches per year In such areas the growth period lasts throughout a fairly long summer and is terminated by the low temperatures which mark the advent of winter The prairies of the central Mississippi Valley, the Pampas of Argentina, and the Black Earth Belt of Russia are the best-known examples

C. *Short grass, summer pasture type*

The short grass regions of the middle latitudes occur where the annual rainfall ranges from 10 to about 20 inches a year and comes mostly in the spring and early summer. Such areas are generally known as ***steppes***. The grass dies down without harvesting, thus furnishing brown pastures throughout much of the season of drought The best known examples are the Great Plains east of the Rocky Mountains and the extensive steppes of southern Russia

D. *Tundra pasture type.*

This is not a true grassland, but its resemblance thereto is marked The tundra is limited to areas wherein cool to cold weather occurs all year and evaporation is so slow that even moderate rainfall gives rise to relatively humid atmospheric and soil conditions The vegetation is low and sprawling, mostly shrubs and mosses The tundra areas of northern Siberia are the most widely known, but similar conditions prevail over large areas of northern Canada.

IV. **Desert Formations:**

Desert vegetation is tolerant of long periods of drought Under this heading are included cacti forms, small thorny bush, and the great variety of small, flowering plants which appear almost as if by magic following the infrequent rains on the desert

Native animal life.—The native animal life of any region includes all of the wild life of the area; that is, not only the four-footed animals such as are ordinarily thought of, but also fish, birds, snakes, and insects. Since animals subsist upon plants or upon each other, the wild life of any region is, in large measure, a response to the environment Yet the animal life is not quite so directly and intimately a reflection of the environmental conditions as is the plant life, because animals have the power to move about, some having developed this ability to a high degree. Birds and some species of fish rank foremost among those with exceptional abilities of migration. Among the land animals, the fleet-footed kinds, such as the antelope, the deer, and the rabbit, show greatest ability in moving swiftly and covering distances. Hence they can overcome environmental handicaps by escaping adverse conditions at various times In contrast with these species are others whose power to roam is limited to narrow confines. They can progress but slowly and only within restricted conditions of environment. Examples are found in the hippopotamus, characteristic of some of the rivers and adjacent marsh areas of Africa, and the alligators and crocodiles, which, although fully equipped with powers of locomotion, cannot travel great distances from their water habitat Many of the insects have small capacities for flight. These are the kinds of animal life which give the clearest and most definite evidence regarding the environmental conditions which prevail within an area.

The native animal life may be classified with respect to its relationship to man Some animals are used for food, while others are valuable only for the materials which they furnish for clothing or shelter purposes. Still others have almost no value to man, but present a negative relationship in that their presence is mostly harmful.

North America, upon the advent of the white man, was a hunters' paradise Besides offering millions of animals of the eatable kind, it was teeming with fur-bearing species The early fur traders were the first white men to penetrate this continent in search of the prized pelts Trapping has been carried on rather ruthlessly ever since, and is still the only means of livelihood for some in the wilds of Canada. In the United States, however, trapping is becoming more and more an avocation and a pastime for youngsters

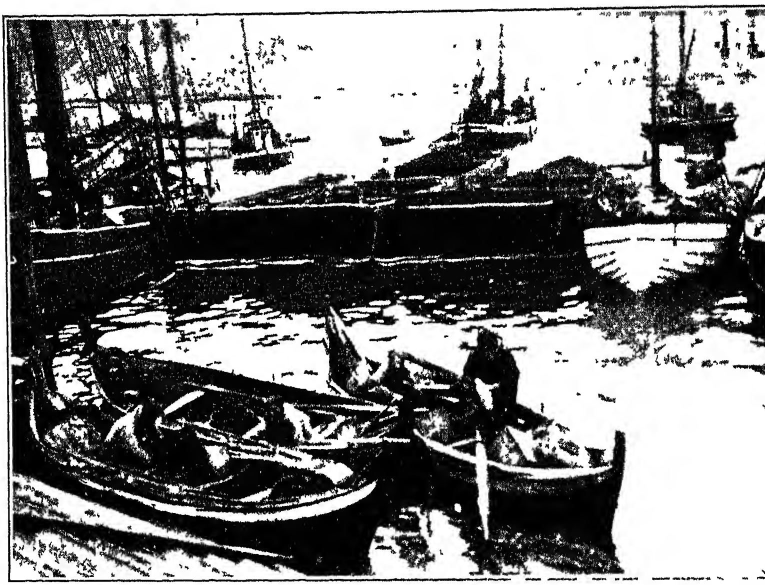


Photo by N. A. B.

Fig. 35—Hammerfest, Norway. Lapps in small boats in foreground engaged in fishing for subsistence purposes; larger boats belong to commercial fleet.

The greatest hunting ventures are now a matter of history. In the beginning of the nineteenth century whaling ranked among the foremost hunting expeditions. In 1850 more than seven hundred American ships scoured the oceans for this prized mammal. Today whales are relatively scarce. Sealing was likewise once an industry of major importance. In its heyday it was carried on so ruthlessly that seals were virtually extinguished within a century and a half. Whereas millions of

seals formerly disported themselves on the shores of Antarctic seas, today they are so scarce there that commercial sealing has practically ceased The northern seal barely escaped a like fate Thanks to the United States government, unscrupulous killings were stopped just in time to spare the seal from the fate of the dodo.

Today, hunting as a means of livelihood is restricted to the more unfrequented portions of the earth. In such places, it is usually closely associated with fishing The Eskimo's life is entirely dependent on the wild animal life about him and upon the fish in the sea. The Indians of the more remote portions of Central and of South America depend largely on the chase and the stream for sustenance. Fishing has remained a more permanent enterprise than hunting for the simple reason that man has not displaced the fish in their habitat as he has the wild animals in theirs

Fishing may, for the sake of convenience, be divided into inland fishing and marine fishing The former, as the term implies, connotes fishing in inland streams and bodies of water. The restricted areas of such waters and the vigor with which fishing is usually carried on leads to rapid depletion of the fish population. This has brought about the necessity of stocking such waters through activities of governments and private individuals. In the United States, millions of young fish are raised yearly in hatcheries for stream and lake distribution. Various European countries engage in a like practice, and private fish-culture is an important industry also in China and Japan Population pressure in these countries compels the maximum use of every inland stream and other unit of water as well as of every unit of land. Fish are raised in individual ponds with the diligence that we raise fine cattle or poultry Much-needed food is derived in this manner.

Marine fishing may be divided into commercial fishing and subsistence fishing. The Fuegian Indian on the southern tip of South America is pleased if his catch of the finny tribe satisfies his daily appetite In the tropical lands, fishing on a subsistence level sustains the lives of many thousands of people.

In the extratropical regions, vast fishing enterprises on a commercial scale are carried on. The most prominent fishing grounds are those of the North Sea, the fishing grounds off the coast of New England and Newfoundland, and the seas adjoining Japan.

Agriculture.—Agricultural activities refer to all of man's labors related to the cultivation of the soil and to industries which are directly dependent upon it, such as the production of livestock. These activities are prompted by one of two main purposes; namely, (1) to supply local wants and needs, or (2)

Photo by N. A. B.

Fig. 36.—Subsistence agriculture in Honduras. Banana trees shown at left of house, in garden of various food plants.

to furnish that which other people desire. The first named is termed subsistence agriculture and the latter commercial agriculture.

Subsistence agriculture is perhaps the oldest systematic pursuit of civilized man. Regardless of whether early man was first a herder of beasts or a tiller of the soil, such activities inevitably led to a degree of cooperation and group activity. Although this achievement was fundamental to the progress of mankind, it represented but one rung in the ladder of progress.

The term *subsistence agriculture* is a relative one and varies

in significance as to time and place. Whereas all agriculture was of this nature in its earliest stages, today we find many gradations, from the most primitive to the most technical and specialized. Efficient methods of transportation were perhaps the most potent factors in restricting areas of self-sufficiency Since the seas provide the easiest methods of conveyance, littoral areas responded first to opportunity of exchange. The Mediterranean Sea serves as a case in point Commerce, in some form or another, has been important on this body of water throughout historic times. Rivers of gentle gradient flowing through well populated areas have ever been commercial highways. The Nile, the Tigris and the Euphrates, and the Rhine serve as examples

Railroads and steamships have widened the horizon of trade and commercial relations The corn farmer of Iowa, the wheat producer of Alberta, and the lumberman of Washington exchange their products for coffee, cacao, banana, spices, and other products of the lower latitudes Each region may now specialize in the production of commodities particularly adapted to its environment and exchange surplus products with far-away lands. Even the silk producer of Japan and the tea producer of China, who raise most of their own food products, are within the orbit of commercial agriculture. Today subsistence agriculture in its unadulterated form is restricted to some of the unfrequented places of the various continents and countries

Commercial agriculture bespeaks specialization in the production of agricultural products and in the exchange of surplus products for the many other needs of the producers. Agriculture in most of the progressive, industrial nations is now on this basis. The potato producer of Maine, the cranberry producer of Massachusetts, the ranchman of Wyoming, and the coffee producer of Brazil are but a few illustrations of this type of activity.

Forestry —Civilization owes a great debt to the tree. Multitudes of instruments and devices are easily made from it to till the soil and to kill the beast or the human enemy. Seaworthy

ships could not have been made by our forebears without the products of the forest The fruits of trees are a valuable adjunct to the diet of man It is sometimes assumed that forest products, particularly wood, are becoming less important This impression, however, is erroneous. Our paper mills are continually making greater demands for wood pulp New and novel demands for wood are arising which more than offset the declining use of lumber for building material and other purposes It is also to be remembered that our uses of tree products—such as rubber, cacao, coffee, tea, nuts, and fruits of many kinds—are expanding

Forestry may roughly be divided into logging and the search for forest products The more important trees for logging purposes are cedar, mahogany, teak, oak, pine, fir, and spruce. The more popular forest products are gum, latex, cork, herbs, rosin, tannin, wild fruits, and nuts.

Forests generally occur in the more humid portions of the earth The tropical rain forests of Central and South America, Africa, southeast Asia, and northern Australia represent the most heavily forested areas of the world. So many species of trees find these regions favorable for growth that the resulting mixed stand discourages extensive forest exploitation in those hot, humid lands. Poleward, where climatic conditions are more severe, fewer species survive, and thus solid stands of the most fit result. This is a factor of high economic significance in logging and lumbering operations

Extractive industries.—The extractive industries refer to those enterprises which withdraw irreplaceable natural resources from the earth for human use Since the many minerals are limited at or near the earth's surface, depletion must eventually lead to discontinuance of "robbing" at any one place. The German term *raubwirtschaft* (robber industry) expresses accurately the nature of the industry.

Mining, quarrying, and drilling are the more common methods of gaining the desired mineral substances. Mining may be carried on either by surface operations or by underground workings Iron ore is so abundant at or near the earth's surface

that in many places it is obtained by steam shovel operations Coal, although exposed in many regions, is usually obtained by the use of shafts and tunnels. Metallic ores, such as copper, gold, silver, lead, and aluminum are derived by either or both of these methods

The removal of stone, clay, sand, gravel, or other rock material from its natural position is termed quarrying. Another group of minerals, such as petroleum, natural gas, sulphur, and salt are obtained by drilling and pumping. The operations of

Courtesy, Istituto Nazionale per l'Esportazione, Rome, Italy

Fig. 37. A huge blast in a marble quarry near Carrara, Italy. Magnitude of operations indicated by the different levels and the apparent small size of buildings in lower center.

oil wells, quarries, sand and gravel pits, and clay pits all are forms of mining and all are extractive industries

Manufacturing and mechanical industries.—Manufacturing and mechanical industries refer to those enterprises in which raw or semi-finished materials are converted into finished or more nearly finished products and also to those tasks in which labor is applied to the construction or repair of things Converting iron ore to pig iron is a form of manufacturing which uses natural raw material and furnishes a semi-finished prod-

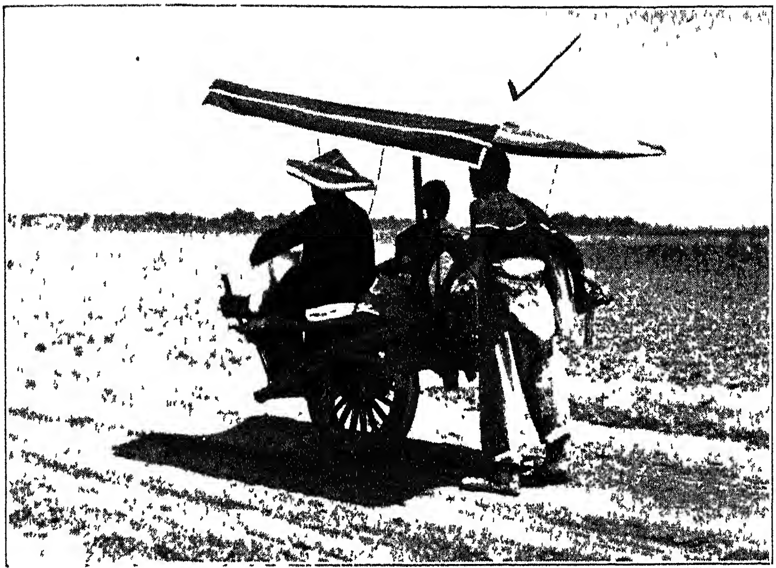
uct. This semi-finished product, pig iron, then becomes a raw material for further processes of manufacture, such as the making of cast iron, malleable iron, and steel These products, in turn, are the raw materials used in other industries wherein the iron or steel is fashioned into shapes needed in instruments, machinery, tools, and tubes of various kinds.

Manufactures are generally classified as "heavy" and "light" types. In the heavy manufactures the ratio of skill and effort expended in proportion to the volume, weight, or value of the product is low. For instance, in the construction of a freight car, the amount of skill and effort applied to a unit of weight or volume is much less than in the construction of watches and clocks Again, the sawing of lumber represents a task of less skill than the construction of typewriters and adding machines. The latter activities represent light manufacturing. The distinction between heavy and light manufactures is a relative one. The terms may also be applied to industries of the same type, in which similar materials are manufactured. In such cases weight of product and skill in workmanship are the criteria. Cotton goods, for instance, may be of the heavy or the light kind, the former term designating coarser, rougher, heavier, and cheaper goods, whereas the latter term indicates light and more costly goods.

Generally speaking, the labor in heavy manufactures is of a less specialized, less technical nature than it is in light manufactures. This is an important factor in the mobility of these respective industries. Heavy manufacture, with its less skilled labor requirements, can shift more readily as the exigencies of a changing industrial world require. Light manufacture, on the other hand, must remain where skilled workmen reside. Strange as it may seem, the latter are relatively immobile.

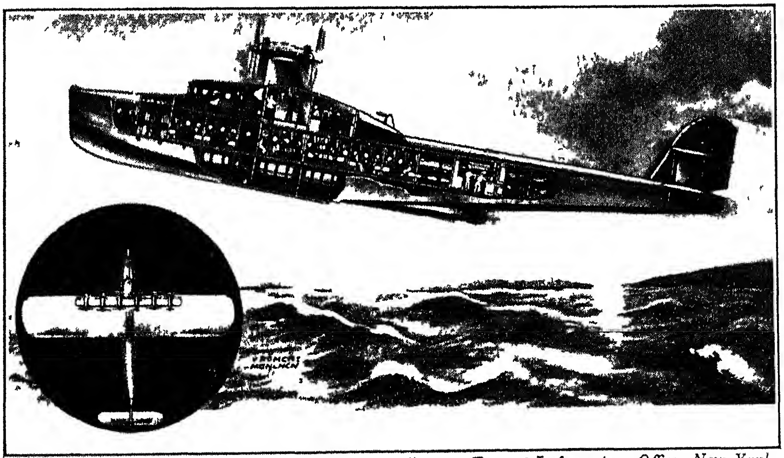
Transportation and communication.—Transportation and communication activities are the many enterprises which effect the conveyance of goods of commerce, and also of man and his messages. The terms should be interpreted broadly enough to include the maintenance of the many plants which are necessary for these operations.

The means of transportation and communication have changed so greatly from time to time that enumeration is neither feasible nor necessary. Within historical times, slaves furnished the motive power for crude vehicles and ships A



Courtesy, Dr George B Cressey, Syracuse University

Fig. 38.—Primitive transportation of passengers in China.



Courtesy, German Tourist Information Office, New York

Fig. 39. -Modern passenger transportation. Large German hydroplane, the "Do X." It is provided with 12 motors, has a span of 125 feet, length of 131 feet, and height of 33 feet.

survival of this method is to be seen in China, where the coolie with his rickshaw is literally a beast of burden The use of beasts for motive power marks an advance over the human method of transportation. For this purpose horses, asses, cattle, camels, dogs, llamas, elephants, and the reindeer are commonly used. However, the most advanced means of transportation utilize power obtained from mineral fuels or from falling water. By means of steam, gas, or electric engines, tours formerly requiring years and months of time can be completed in days and hours.

The importance of transportation is such that most of our metropolitan areas would be reduced to a serious state of hunger and starvation in less than a week if the importation of foods should cease. Rural areas would likewise be reduced to a subsistence level if transportation were discontinued.

Trade and commerce.—Trade and commerce are closely related to transportation and communication Where the latter exist, agencies must be instituted to bring about an orderly exchange of the various products which are available. The exchange of goods—that is, buying and selling- and the agencies which in part render possible or encourage such activities are included in the expression *trade and commerce.* Among the more common institutions of this kind are banks, insurance companies, grain exchanges, and wholesale and retail establishments.

Professional and public services.—Professional and public services are positions requiring either special training or public trust Educators, doctors, lawyers, religious workers, and public officials are the outstanding workers in these fields. Their professions are noted for the public leadership they provide, and their trust is a serious one. It should be a matter of public concern to retain them at the highest possible standards.

Domestic and personal services.—No classification of occupations would be complete without mention of the distaff side of life A great poet once said, "Man works from sun to sun, but woman's work is never done" It is submitted herewith that the work of woman has been and is of such significance

that no writer needs to attempt to appraise its importance

Under personal services are listed occupations in homes, hotels, laundries, cleaning and dyeing institutions, and many others

Relationships between economic activities and natural environment of any given region.—Geography may be defined broadly as the study of human adjustments to terrestrial reality. Everywhere people are in contact with agencies of an external world which elicit thousands of adaptations A proper approach to the subject therefore requires a knowledge of the physical world on the one hand and an understanding of the human beings on the other. These two geographic factors, as we may call them, act and react in such numerous ways that causes and effects are most intimately associated, and sometimes it is difficult to classify precisely all the elements involved.

It is sometimes claimed that scientific progress has rendered man largely independent of his environment, that man has "conquered" nature It is quite true that explorers may now fly over the poles in relative comfort, that canals have been cut through land barriers, and tunnels through mountains; such facts merely illustrate that man is active in changing given environmental features. By and large, however, he still remains a subject of circumstances in no small degree

Increased industrialization has not rendered man independent of his environment. In most instances he has become more appreciative of that which is about him The iron industry centered around our Great Lakes would shortly sink into insignificance if either the iron ore or the coal were depleted. Again, the distribution of iron ore over the world and its utilization are of great significance and interest to the American iron and steel industry Great development elsewhere might readily cause reduced foreign demands and therefore lead to forced restriction of domestic output.

The human factor in development and progress should not be underestimated. Man, with his intelligence, rightly or wrongly used, is himself one of the most potent of geographical

factors The presence of large cities suggests the extent to which man may change environment Man has cleared millions of acres of natural forest lands Such alterations frequently lead to rapid changes in land surfaces and even in the character of the soil For instance, much of northern China is seriously eroded, gullied, and ruined because of the removal of trees and other vegetation. This situation in turn greatly aggravates the local problem of flood control.

If man wishes to supply his material needs, he must obtain things from his environment. As different environments give rise to different products, man must adjust his activities so that his efforts yield him the utmost in satisfaction. Such products as he wrings from nature may either be consumed directly or they may be exchanged for other products of different places. Whatever his work, it is termed his economic activity

It cannot be presumed that human adjustments in any place are perfect. Nearly every day additional resources are discovered in different areas of the world. Once their value becomes known, adjustments may be made to secure the reward their exploitation offers Within certain broad limits, therefore, nature needs to supply the wherewithal for man's activity or to sanction it.

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CHAPTER V

Introduction to the Land

WHAT is the land? Such an inquiry addressed to people of different locations and pursuits would bring a medley of responses. Even if the essence of such responses might reflect a bookish knowledge of the term, the real significance of the word as thought of by the several groups would be as variant as the points on the compass. To the apartment dweller of New York City the land suggests something of which he sees little and understands less To the Eskimo the land is but a seasonally exposed material that is neither attractive nor particularly significant. His food of fish, blubber, and reindeer meat suggests little of the importance of a good earth. The farmer of Norway thinks of the land as hilly and stony and hard to conquer, whereas the farmer of Iowa thinks of it in huge terms of corn and hogs.

Readers of Miss Buck's novel, *The Good Earth,* are made aware of an attitude toward the land that is almost poetic in intensity. In this novel the soil and the elements are pictured as the fickle masters over the life and death of teeming millions of ignorant, stolid Chinese. There will come to mind vivid pictures of Wang Lung and O Lan ministering to the earth Every growing plant receives the tending care of their anxious hands. If the land produces generously, a few ounces of meat may be procured for a holiday; if it yields niggardly, a young daughter must perhaps be sold into slavery and infamy. Wang Lung loves to walk in newly turned soil, to feel the earth with his unclad feet He loves to rest and even sleep in a sun-warmed furrow so that he can feel and smell the earth. He hopes to be buried in the better earth

Throughout human history man has been aware of the land as a fundamental necessity in the scheme of making a living Royalty has ever paid homage to the dignity of labor on the land, although it has not always been generous in monetary compensation. Artists have immortalized on canvas the workers on the land and poets have sung paeans of praise in their honor Even though land has long held such prominence in thought and deed, to define it accurately is not easy. What is land?

The land is defined as the *exposed portion of the lithosphere;* that is, the portion not covered by water Exceptions are made for small bodies of water which are of temporary nature and of such slight extent that they do not impair the general tract of which they are a part Large rivers and lakes, and shallow waters around the seashore are not included Land exists because of the uneven surface of the lithosphere, which causes some parts to project above the oceans. The total area of the oceans is about 143,000,000 square miles, whereas the total area of the land is only about 54,000,000 square miles. The highest point on the land is probably Mount Everest in the Himalaya Mountains, which reaches an altitude in excess of 29,000 feet above sea level. The lowest-lying land on the earth is in the great valley occupied by the Dead Sea, 1,268 feet below sea level. About 60 per cent of the land lies at less than 6,200 feet altitude, and it is on this portion that most of the people of the earth live.

Physical environment fundamental in economic life. The three fundamentals of the physical environment are land, air, and water. In its broadest sense, environment is the principal determinant of man's economic activities. For illustration, a strictly sea environment leads to the life of the sailor or the fisherman. Some sailors find their seat of activity on the shallow waters of the bays and gulfs along the various coasts, while others are the deep-sea navigators of the ocean highways. Fishermen vary in their occupations from the clam diggers and lobster trappers working in the shallow coastal waters to the sturdy and daring seekers for the whales of the polar seas.

The air alone does not constitute a self-sufficient basis for very many human activities. Aviation is the most conspicuous example of a human occupation within a strictly atmospheric environment. The atmosphere does, however, constitute an essential part of the environment of all terrestrial and marine activities, inasmuch as it is the outer enveloping sphere of the lithosphere and hydrosphere. As an environmental factor, its importance is greatest in two respects: (1) it is essential in supporting oxidation and thus maintaining life processes; and (2) in its weather and climate phases it exerts considerable influence on plants, animals, and man.

The land is the home of man and the seat of most of his activities. It gives rise to farmers and herdsmen, who obtain their living directly from the products of the soil, as well as to the foresters and lumbermen, who reap the products of ages of growth which occurred prior to their coming. The land has also its hidden treasures which serve as the bases for the mining industries, varying from rubies, diamonds, and other precious stones, to the realms of metallic minerals and the stores of mineral fuels, notably coal, petroleum, and natural gas. Thus, of the three major phases of environment, the land is of first importance because of its direct relationship to man's sustenance, to his travels, and finally to his last resting place. "Dust thou art, to dust returnest" symbolizes the poet's appreciation of the fundamental significance of land in the scheme of man's existence.

The content of the land.—The materials which make up the solid portion of the earth are broadly classified into two main groups, namely, minerals and rocks. As used in geography, these terms presuppose natural earth substances and so do not include manufactured products which may be of the same or similar compositions. In its broadest sense, rock refers to any of the *solid part of the earth.* It does not imply any particular degree of coherence. Sand, dust, silt, and clay are forms of rock, even though they may be in granular or powdered state, and as thus defined rock also includes coal and solid bitumens. As used in this sense it does not refer to any particular kind or

class of earth material. The only specification is that it must be solid, but induration is not implied. On the other hand, the term stone implies coherence—that is, a certain degree of hardness—and it is therefore used as a rock term in many cases, notably such as limestone and sandstone. Ordinary plaster sand is a phase of rock, but if the sand grains are found fairly well cemented together, so that they resist crushing, they are called sandstone

As above used, rock is given its broadest possible definition. In many cases, however, the term is used in a restricted sense, and then it has a concise and definite significance. All rock is made up of one or more mineral constituents, and in their composition rocks vary from those which are quite simple, perhaps made up of only one mineral aggregate, to those which are so complex that they include a large number of minerals. In all cases, however, rocks have mineral content.

A mineral may be defined as a *natural earth-substance which has a definite, essential chemical composition*. Minerals may have various non-essential constituents without impairing the validity of the definition For example, quartz, the most common mineral of the land, is essentially a natural earth substance made up of silicon and oxygen in the ratio of 1 to 2; namely, silicon dioxide. In its pure state it is colorless, odorless, and tasteless, but most quartz has some color due to the presence of impurities, such as iron oxide, manganese compounds, carbon, rare earths, and other foreign matter. Pure quartz is not so common.

A particular kind of rock is defined as a *natural earth-substance having a definite, essential mineral composition*. Thus, a limestone must be made up largely of lime—that is, calcium carbonate—but it may have non-essential ingredients and impurities, such as clay, sand, and iron compounds. Thus defined, there is a distinction between rock in its broadest sense and rock referring to a particular kind. *Rock*, as broadly used, does not imply hardness or coherence, whereas *a rock* does imply something of the quality of stone, and it implies also a relatively definite mineral composition.

Important properties of rocks and minerals and their economic relationships.—Inasmuch as some of the common minerals and rocks enter largely into economic life, an understanding of their essential properties is of value From the viewpoint of economic geography only those materials are selected for study which are of importance to practically all individuals in their various walks of life.

In the business world men are continually confronted with problems dealing with construction materials. In addition to the demands of their own private enterprises, they are called upon to act on advisory committees in the construction of churches, school houses, libraries, and other public buildings, and in all such cases questions involving the choice of materials for construction must be decided. Even if one constructs but a modest residence for his own use, he must choose the materials for the foundation, for the walls and roof, and the materials to be used inside. In order to function intelligently when these problems arise, the citizen should have some degree of familiarity with the common building materials and should not be compelled to depend wholly and blindly upon the advice of others.

Minerals of major economic importance.—The most common minerals may be thought of as belonging to three broad groups; namely, (1) those which are the major components of the common rocks, (2) those which are used as found in nature or without any important processes of manufacturing, and (3) those which serve as sources of fundamental raw materials in industry, the ores being the best known examples of this group

The number of minerals of major importance in each group is not large. Among the rock constituents, quartz, feldspar, mica, hornblende, calcite, gypsum, and kaolinite rank foremost, and they make up the great bulk of the common rocks of the land. Among those in the second group, sulphur and common salt (halite) have important uses in various phases of industry, and for sanitary and culinary purposes. There belong also nitrates, phosphates, and potash, because of the widespread demand for mineral fertilizers. In the third group are the

minerals which serve as the sources of fundamental materials in industry Among these, iron, copper, aluminum, lead, zinc, and tin are of such basic importance that intelligent citizenship demands some acquaintanceship with the ores, the raw materials from which the metals are derived The threefold classification of the common minerals thus outlined (1) major components of the common rocks, (2) minerals used as found in nature or without much change, and (3) minerals which are sources of fundamental raw materials in industry -is based on their economic relationships and is designed to be useful in learning the significant characteristics of each type as studied

Rock constituent minerals: *Quartz.*—Quartz includes a large number of varieties which differ in physical properties, such as color, crystallization, and fracture They all, however, have as their essential chemical constituents silicon and oxygen in the ratio of 1 to 2, and are therefore designated by the symbol SiO_2. Although they differ widely in appearance, they have the common quality of a degree of hardness that will easily scratch glass, and all the varieties are relatively resistant to weathering The most common kinds are milky quartz, smoky quartz, quartz crystal, rose quartz, opalized wood, agate, jasper, and amethyst.

Hardness and relative insolubility in water or weak acids are the outstanding properties of quartz. While it does not decay readily, quartz shatters under the influence of temperature changes; that is, it suffers *disintegration* rather than *decomposition* Upon disintegration, the resultant small particles are known as *sand* Quartz is one of the most common constituents of river sand and gravel.

In the soil, quartz serves its most useful purpose in giving body and friability It makes the texture relatively open, and therefore facilitates the ready movement of ground water and aeration The physical condition of the soil is thus made much more favorable for penetration of plant roots and for cultivation than would be the case otherwise.

As a building material quartz owes its high importance to the

fact that it is the principal constituent of sand The sands used in plaster and in concrete work must withstand the influences of the weather and lend themselves readily to induration by cement. These functions are effectively served by quartz sand.

Feldspars —The term *feldspar* has come to us almost unchanged from the German and means "rock of the field," thus indicating its common occurrence in some places It should be thought of not as a single mineral, but as the designation of a group of minerals which have similarity of chemical and physical properties.

The feldspars are quite brittle and break with an uneven surface Because of impurities, they have different colors usually varying from a light flesh color to brick red They are not quite so hard as quartz.

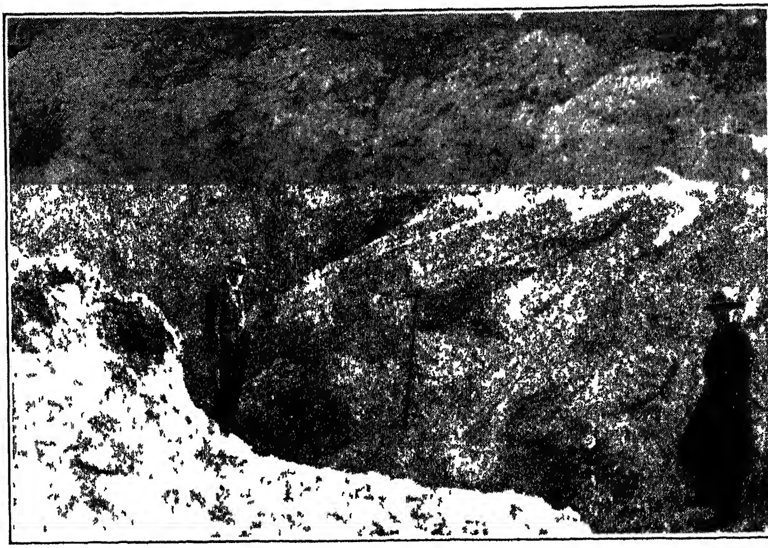
The feldspars are not so resistant to weathering as is quartz, and they break down by both decomposition and disintegration The principal products of decomposition are clay, sand, and soluble salts It is thus seen that feldspar is of great importance in the formation of soils, particularly since it is one of the principal sources for clays and for the mineral salts which are essential in the soil as plant foods Industrially, feldspar is used in the manufacture of fine chinaware and some grades of refractory tile.

Mica. -The term *mica* is also used for a group of rock minerals rather than for a single kind. The micas are characterized by almost perfect cleavage in one direction, and by the toughness and flexibility of the sheets into which their cleavage permits them to be split. There are several kinds of mica, but only two of them are of common occurrence and major importance These two are muscovite and biotite, the former being light colored and almost transparent, the latter being black and practically opaque; both are soft enough to be cut easily with a sharp knife

Where exposed to weathering, the micas break down readily into small particles, but as such they withstand decomposition remarkably well. Small mica flakes are common in many of

the rocks which have resulted from the deposits of sands and muds They can often be recognized by their lustrous, shining, and flaky properties.

The great expansion of the electrical industries has been the principal cause of the increased production and utilization of muscovite. The unusual combination of physical properties which characterizes it—namely, its transparency, elasticity, high dielectric strength, and perfect cleavage—makes this mineral indispensable in the manufacturing of certain types of



Courtesy, United States Bureau of Mines, Washington, D. C.

Fig 40.—Large mica crystals, Bumpus and Perham mica quarries, Maine.

electrical equipment. One widespread and important use is in the manufacture of the transmitter button, an integral part of the modern telephone instrument Muscovite is also used in the manufacture of lightning arresters, condensers, commutators, and other special types of instruments. Because of the iron content, which gives biotite its dark color, it is not suitable for electrical insulation purposes, but it has nevertheless quite a variety of industrial uses.

Ground mica is sprinkled on roofing material before rolling to prevent sticking of the layers in the rolls, and, for the same

reason, it is extensively used as a tire powder. It is also used as decorative material on wall paper, as Christmas tree "snow," and in special paints Finely ground and mixed with grease, it is used as a lubricant The tonnage of ground mica used yearly for these various purposes reaches a considerable figure

The total quantity of mica sold annually by producers in the United States varies from 6,000 to 10,000 short tons New Hampshire and North Carolina lead in production, the former having held first place until recently, but lately North Carolina has taken a commanding lead. The two states together

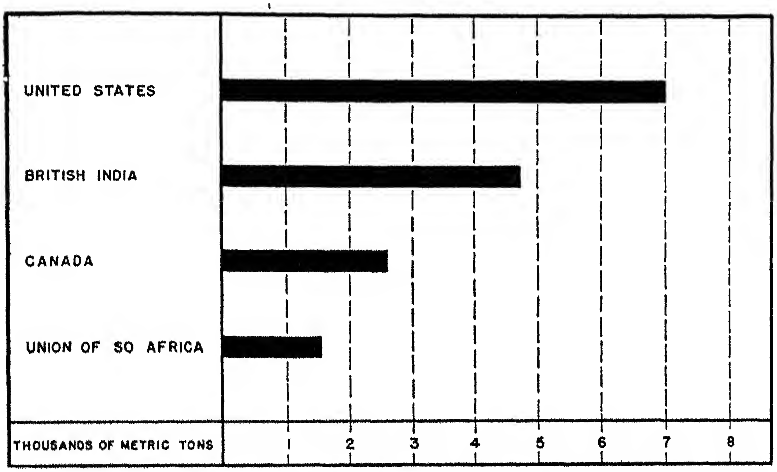


Fig. 41. Mica production of leading countries. Average 1926-1930. (Source of data: *Mineral Resources of the United States*, Bureau of Mines, Washington, D.C.)

account for about 75 per cent of the total production in the United States. A number of other states have small production, notably South Dakota, Colorado, New Mexico, and Alabama. Since mica is so widespread in its distribution, there is always the possibility that valuable discoveries may be made in any mountainous state.

Although the United States is the world's foremost producer of mica, domestic production is insufficient to satisfy the industrial needs. The annual imports ordinarily exceed 5,000,000 pounds, most of which are supplied by India and Canada. Mica mining is assuming importance in the Union of South Africa,

and this source gives promise of entering actively into the world markets with substantial supplies.

Hornblende.—Hornblende is the most common of the hard, black, brittle, rock-forming minerals Its hardness is slightly less than that of orthoclase feldspar. It may be of various colors, but dark brown and black occur most commonly. Hornblende has no direct economic use, and, therefore, its geographic significance is based upon its presence in many rocks and the products—sand, clay, and soluble salts—which result from its weathering

Calcite—Calcite is one of the most common and widely diffused minerals. Although generally found as a constituent of sedimentary rocks, it occurs also in igneous rocks. The principal reason for the importance of calcite is its prominence as the chief constituent of chalks, limestones, and marble. When pure, calcite is white or transparent, but as found in nature it is usually colored with some impurities. It can be scratched readily with a knife The common test for calcite is its effervescence in cold, dilute hydrochloric acid.

The direct economic importance of calcite is based on the optical properties of the crystals and on their value as museum specimens; for these purposes there is a moderate market. More important than the demand for calcite in its crystal form is the demand for the products of the rocks—chalk, limestone, and marble—of which it is the principal constituent.

Gypsum—Gypsum usually occurs imbedded with sedimentary rocks. When pure, it is white or transparent, is softer than calcite, and can be ground by the teeth without discomfort In its natural state it is rarely pure and therefore it is usually colored, varying from light gray to dark brown.

Gypsum is essentially a sulphate of lime with chemically combined water. In smaller quantities it often occurs in a crystalline form, usually nearly transparent, known as *selenite*. Alabaster, a fine-textured dense and white variety of massive gypsum, has considerable use for ornamental work, such as vases, hand-carved statues, and other articles for interior decorative purposes.

The principal uses of common gypsum are in the preparation of fertilizers and in the manufacture of cements of various kinds Ground rock-gypsum is valuable to correct acidity of some soils, and when used in that way it is known as land plaster When heated to moderately high temperatures, a process called *calcining*, it makes the well-known plaster of Paris. This product is the basis for the manufacture of various hard finish plasters used in buildings and for the plaster boards which have won popularity in recent years. Ground gypsum has important uses also in the manufacture of crayons

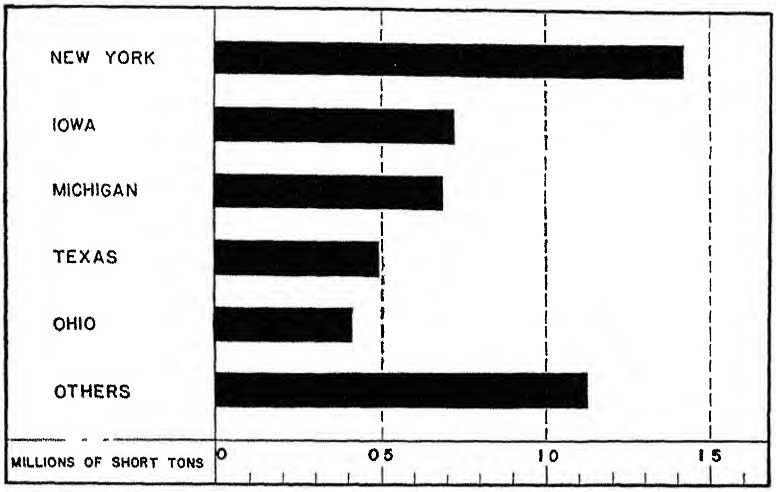


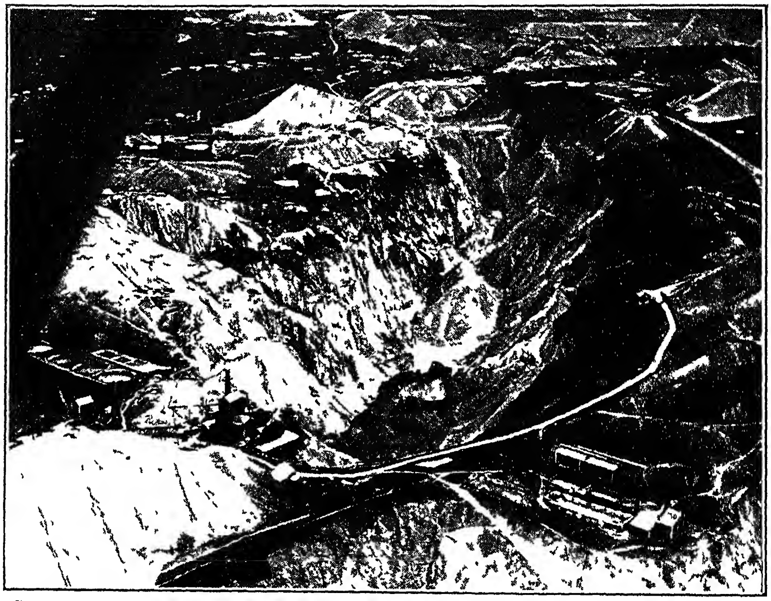
Fig. 42. Principal gypsum producing states. Average 1926-1930. (Source of data: *Mineral Resources of the United States*, Bureau of Mines, Washington, D. C

and as a retarder in Portland cement In small quantities it serves a useful purpose in preventing the too rapid setting or hardening of cement mortar.

The amount of gypsum mined or quarried in the United States reaches approximately 5,000,000 tons per year The leading states are New York, Michigan, Iowa, Texas, and Ohio Some gypsum is imported annually from the maritime provinces, New Brunswick and Nova Scotia This is used principally in the northeastern states where water routes make the Canadian sources most accessible

In world production the United States holds first place by a wide margin, its output being nearly double that of France, its nearest rival. Canada and the United Kingdom hold third and fourth places respectively.

Kaolinite—Kaolinite, or kaolin, is important because it is the essential and most common constituent of clay. If pure, the color is white, but in its natural state kaolinite is often tinted yellow, brown, or gray by its associated impurities. When



Courtesy, English Clays Lovering Pochin and Co , Ltd , and British China Clay Producers' Federation, Ltd

Fig. 43.—Aerial view of a kaolin mine in Cornwall, England. Magnitude of workings indicated by roads and buildings.

rubbed between the fingers, it has a characteristic smooth, greasy or unctious feel, which helps to distinguish it from other similar materials Using this test, its presence in soils can be recognized by rubbing out the gritty particles and seeing whether there is the smooth, unctious residue of clay. It has also a characteristic odor by which its presence is indicated, an odor which, once learned, is ordinarily not forgotten.

The direct economic uses of kaolin are based principally upon

its refractory qualities These give it high place in the porcelain and chinaware industries For example, the world renowned Haviland china is made from exceptionally high grade kaolin, which has resulted from the weathering of massive feldspar bodies near Limoges, France The kaolin deposits of Cornwall, in southwestern England, are the most important of this type in the world; they not only support a prosperous British chinaware industry, but they also supply large quantities for exports.

The minerals thus briefly considered in this chapter are the most common rock constituents, but of course do not comprise an exhaustive list In varying degree they all have some direct economic importance. Their double significance is such that they cannot be omitted from consideration if we would have an intelligent understanding of the land

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CHAPTER VI

Geographic Importance of the Common Rocks

IN this chapter we are concerned only with the solid or indurated zone of the lithosphere, commonly referred to as *bedrock* In most places the bedrock lies under a mass of rock debris varying from a few inches to many feet in thickness This covering mass is not consolidated, although it may be quite compact in some cases, it is not stone-like in its hardness. Since it occurs as a cover overlying the hard rock below, it is known as *mantle rock* The mantle rock is the zone which may

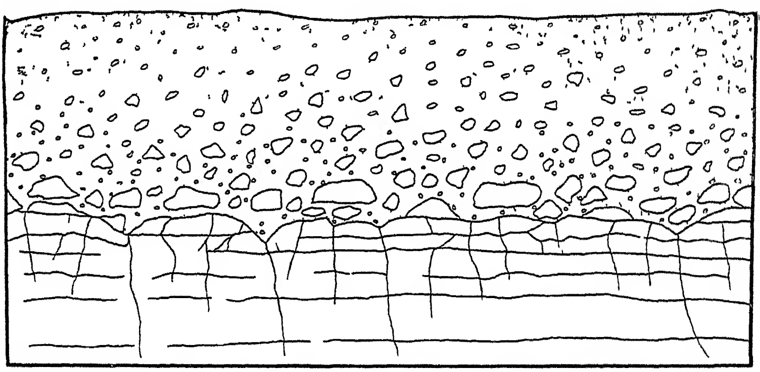


Fig. 44—Sketch to illustrate unconsolidated mantle rock developed from underlying bedrock.

give rise to soil; that is, it is the parent material out of which soil may be developed through the action of various weathering processes and by changes brought about by organisms. The mantle rock, although often erroneously referred to as soil, is merely the raw material which, by undergoing further chemical and organic changes, may become true soil.

The number of kinds of bedrock of common occurrence is comparatively small, and the task of becoming familiar with

their principal characteristics is not very difficult While it is not our purpose to elaborate upon the origin and characteristics of these rocks, brief consideration is necessary if their uses and importance in industry are to be understood In a broad sense, the geographic significance of bedrock is based on three fundamental relationships; namely, (1) its importance in determining the characteristics of the mantle rock, (2) its use as materials for construction, and (3) its use in industry, especially in manufactures

Bedrock an important aspect of the land.—Where bedrock is close to the surface of the land, it is an impediment in the excavation of cellars, in digging ditches, and in the construction of other works of similar nature In such cases the labor cost is such an important factor in planning buildings that it sometimes determines the sizes and types of structures to be erected On the other hand, bedrock close to the surface has its compensating features in construction activities, because canal floors and sides need neither pavements nor retaining walls; tunnels, although difficult to make, need but little reinforcement, and bedrock furnishes splendid anchorage for bridge piers and foundations for heavy buildings New York City, for example, has spent enormous sums for the construction of subways and in the excavations necessary for her extensive office blocks Nevertheless, the crystalline bedrock floor has proven to be a real asset, because it has provided a firm foundation for the world-famous skyscrapers of the metropolis

Where the solid bedrock lies deep below the surface and excavations in the mantle rock are therefore relatively inexpensive, this favorable factor is offset in part, at least, by the necessity of making costly floors and retaining walls. For larger buildings the foundations are expensive to construct; caissons must be sunk to solid rock and sealed with concrete to serve as supports for the superstructures For example, the great buildings of the business district of Chicago have had to bear huge construction charges because of the high cost of their foundations. But under these conditions, where the excavations are made altogether in unconsolidated materials, small bridges, irrigation

ditches, drainage canals, and ordinary residences and business blocks can be constructed cheaply

Classes of bedrock.—The simplest classification of bedrock is based on its origin, that is, on the possibility or impossibility of tracing the earlier state of existence of the component parts Thus, *primary rocks* are those for which the antecedent existence of the materials which constitute them cannot be satisfactorily determined In most cases heat processes have blotted out the evidences of former conditions of existence. Since most of the rocks of this group show the influence of heat and subsequent cooling, they are often termed *igneous* rocks.

Secondary rocks are those wherein the previous existence of the materials of which they are composed can be accounted for in the constituents of primary rocks. The now existing secondary rocks consist of materials which, having originally occurred in primary rocks, have developed into their present kinds through the changes which normally occur during the processes of rock decay and the transportation and redeposition of the resulting rock particles. Inasmuch as most secondary rocks owe their origin to some form of the accumulation of particles under the influences of water or air, they are commonly known as *sedimentaries.*

A third group of rocks owes its origin to changes which have occurred in the primary or secondary rocks, thereby giving them new properties and new structure features. This group is designated as the *metamorphic rocks,* referring to the inherent meaning of the term; namely, "changed form" Common illustrations of rocks thus classified are slate, derived through pressure effects on shale, and quartzite, derived through thorough cementation and resultant induration of sandstone.

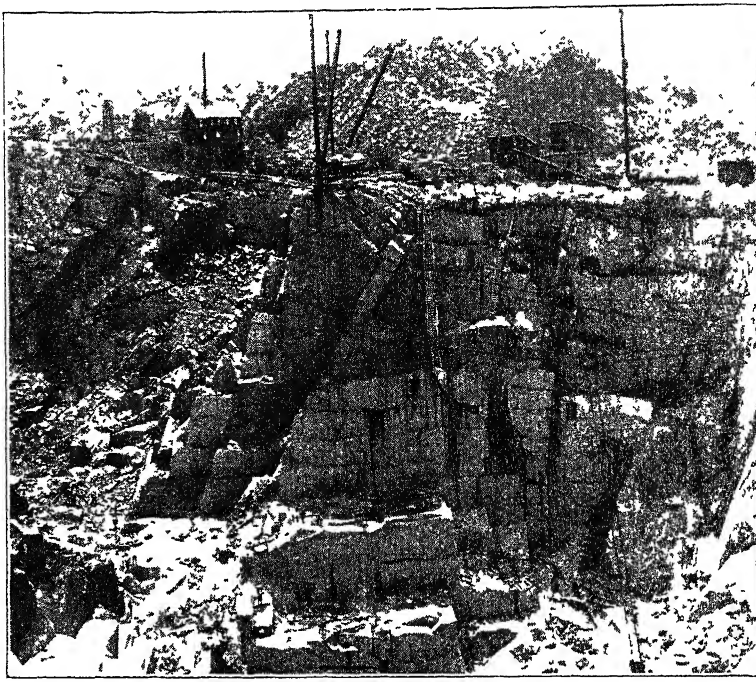
The most common primary rocks: *1. Granite.*—The widespread occurrence of granite in various parts of the world and its adaptability for construction and monumental purposes are perhaps the chief factors in its economic importance. Its mineral components are essentially quartz and feldspar, and most granites also contain mica and hornblende. Owing to the various proportions in which the mineral constituents occur

and to their differences in size and arrangement, there are many kinds of granite The structure is wholly crystalline, the crystals ranging from large to small Granites occur in various colors: some light gray, some reddish or brownish, and some quite dark On the whole, they are relatively durable, this being especially true of the finer textured varities. The coarser crystalline granites are more likely to break down under the influences of marked temperature changes than are the fine-textured ones, but many varieties of the former are quite durable, are capable of taking a high polish, and hence are in great demand for ornamental and monumental purposes Although all granites are compact and hard, most of them are not too hard to work; that is, it is possible to fashion them into desirable shapes without undue expense for labor or equipment

Granites are common in nearly all old mountain areas They are widely distributed in the crystalline Appalachian highlands of eastern United States; they are also found in large quantities in northern Michigan and Minnesota, and in the western mountainous areas In Europe, Scotland is noted for the quality of its granite for monumental and structural purposes. This is true also of the crystalline lands which constitute most of Norway and western and northern Sweden Norway and Sweden furnish large quantities of granite for use in Denmark, northern Germany, Netherlands, and England The granite occurs near the coast, and cheap water haulage makes possible its delivery at low cost for general building and road-making purposes in the plains countries where stone is scarce. The brilliant red granite known as rapakivi, from central Sweden, is used extensively in the Netherlands along the bases of the dikes to protect them from the ravages of wave action. Granite is conspicuous also in the cores of the lofty mountains of southern Europe, especially in the Pyrenees, Alps, and Caucasus

Because of its massiveness and durability, granite is a favorite stone for use in masonry construction It is popular for ornamental and monumental purposes because of its beauty, whether in the rough or finished with a high polish Its attractive quality endures through the centuries, even though

the stone is exposed to the devastating influences of severe weather changes. These properties of beauty and durability have to a large extent caused granite to displace marble for monumental work in areas where the climate is such as to break down weaker materials Granite is also used for paving blocks, railroad ballast, and concrete matrix, although in many cases the expense involved in its preparation for these purposes pre-



Courtesy, Rock of Ages Corporation, Barre, Vermont

Fig 45 —Granite quarry at Barre, Vermont Note extent of workings and massiveness of the granite through comparison with cars and buildings in upper part of picture

vents its successful competition with weaker and cheaper kinds of stone.

In the United States the leading granite producing centers are in the east, from New England to North Carolina Vermont is the foremost granite producing state, granite accounting for more than one-third of her total quarry output. Barre, in the central part of the state, is the most famous granite pro-

ducing district in the United States, and it furnishes the most widely used monumental stone in the country. The popularity of Barre granite is due to its pleasing gray color, its uniformity of texture and structure, its massiveness, and its durability when exposed to the weather. It can be quarried at comparatively slight expense, and can be fashioned into desired sizes and shapes with little difficulty.

The output of granite in Massachusetts usually makes up more than half of the total annual mineral production of the state Massachusetts has a world-famous shrine of granite:

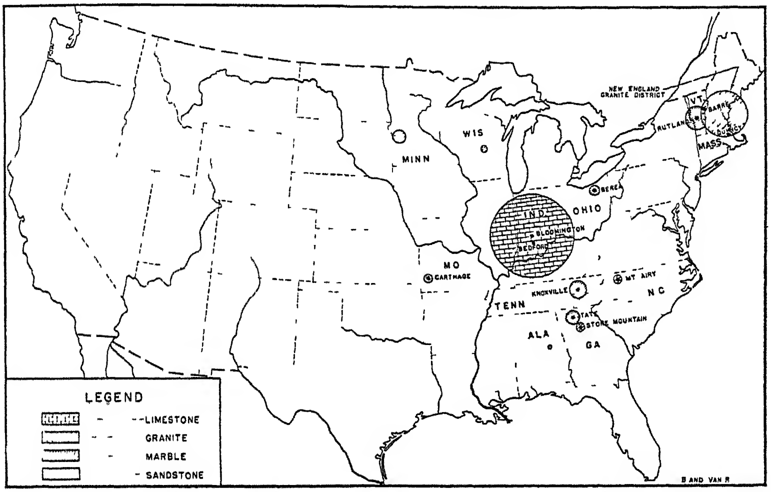


FIG. 46—Production of principal building stones in the United States. Size of circles is proportionate to output of stone in the various centers.

Plymouth Rock, of Pilgrim story It is a granite bowlder, now carefully protected by a canopy constructed over it so that visitors can see it but so that neither man nor weather may destroy it The state has a number of quarries and plants for the preparation of granite for the trade, but those near Quincy, a suburb of Boston, are the most famous This quarry center has been in operation since colonial days. Quincy granite, of an attractive gray color and capable of taking a beautiful finish whether rough or polished, is used for both construction and monumental purposes, the former being the more important

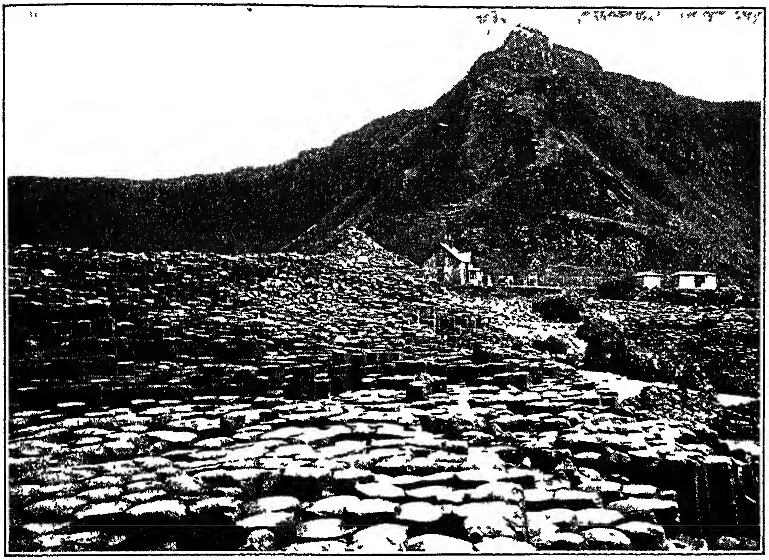
While New Hampshire is less famous for its quarrying industries than either Vermont or Massachusetts, the prominence of granite in its hills and mountains is symbolized in the term, the Granite State Maine's prominence as a granite producer is due largely to the sea-side location of her quarries, where boats may be loaded in sheltered harbors. The quarries of Maine have proven to be a valuable source of supplies for construction materials needed by the eastern seaboard cities The heavy weight of the stone and its low price per ton necessitates cheap haulage from quarry to place of use; this is made possible by the coastal waters which connect Maine with the cities to the south.

Other important granite producing areas of the United States are at Mount Airy, North Carolina, and near Richmond, Virginia, the former famous for its white granite and the latter for its pink. Stone Mountain, Georgia, of worldwide renown because of the monument being carved upon it, is a great mass of fine-textured light gray granite The Wisconsin-Minnesota area also is an important producer of granite—Montello and Wausaw, Wisconsin, and Ortonville, Minnesota, being centers well-known to the monumental stone trade

There are marked tendencies in the granite quarrying industry toward larger scale operations and fewer production plants. From 1909 to 1930 the number of enterprises quarrying granite in the United States dropped from 707 to 427, with relatively little change in the value of the total output Indications are that this number is still dwindling and will likely continue to do so for some years because of the increased efficiency of machine methods of quarrying and stone dressing which are adapted only to large scale operation. Through the economies made possible by modern machinery and power, the handicap of distance to markets is overcome; this invariably leads to the closing down of small rock quarries where the stone is less desirable or where modern mechanical equipment is not available.

2. The basics—The igneous rocks included under the general term of *basics* are characterized by their dark color and the presence of only a small percentage of quartz The most com-

mon examples of this class are diabase, basalt, and various lavas Basic rocks occur as prominent ridges in the Connecticut Valley, where they are commonly referred to as *trap*. They also make up the well-known Palisades of the Hudson and the trap ridges of northern New Jersey and eastern Pennsylvania The most extensive area of basics in the United States is the Columbia Plateau of Washington, Oregon, and Idaho



Courtesy, Associated British Railways, Inc, New York

Fig. 47.—Basalt prisms, forming the famous Giants Causeway, northeastern Ireland. Not all basalt is so distinctly columnar.

On account of the unattractive color, the demand for rock of this group is limited almost entirely to roadmaking purposes, riprap work along streams, and railroad ballast. While the direct industrial uses of trap and basics in general are not very great, these rocks are of importance because they are the source of much of the clay of the land; and their iron content, through oxidation, has caused widespread brown colorings in soils and subsoils as well as in the sedimentary rocks

The most common secondary rocks: *1. Sandstone and conglomerate.*—Most sandstones are composed chiefly of

quartz grains, but some contain many other constituents, such as mica, hornblende, and even feldspar Sometimes clay is present in quantities varying from almost negligible to those large enough to affect the dressing quality and durability of the stone. Cohesion of the grains varies widely; some sandstones are crumbly while others are almost as hard as quartz The colors vary from gray, almost white, to blue, brown, or black. Owing to the widespread occurrence of iron oxide stains, red and brown sandstones are the most plentiful

Although sandstones have wide local use, they do not enter so extensively into construction purposes as do some other kinds of rock, because they are not so uniform in appearance nor in durability The use of sandstone for grindstones and other grinding instruments was formerly important but in later years this demand has been met to a large extent by artificial abrasives

The three states leading in output of sandstone are Ohio, New York, and Pennsylvania. The Berea sandstone of Ohio, the most widely used building sandstone in the United States, owes its popularity to its uniform, attractive gray color, its durability, and the ease with which it may be fashioned into desirable shapes. The output of the Berea quarry center ordinarily accounts for nearly one-half of the total value of sandstone produced in this country Other important quarry centers are the brown sandstones of the Connecticut River Valley, the tan and red sandstones of Minnesota and Wisconsin, and the red sandstone of Colorado

That the number of commercial sandstone quarries in the United States has been declining steadily during the past decades is shown by the drop from 1,158 in 1909 to 271 in 1930 The quarries which are being successfully operated at present are those which can furnish the kind and color of stone demanded by the trade, and which are equipped with machinery for low-cost output Quarries not favored by these factors appear to be doomed

The most common secondary rocks: *2 Clays and shales* — Clay is an earthy substance of fine texture, consisting of a mix-

ture of aluminum silicates with fragments of other materials of either mineral or organic nature Clays become plastic when wet and become stone hard if fired to redness. Consolidated clay is termed *shale,* and ordinarily it manifests a tendency to split apart along the planes of deposition If ground fine and mixed with water, it usually becomes nearly but not quite so plastic as clay

From the standpoint of origin, there are two main classes of clay; namely, residual and transported. Clays from crystalline rocks are made up of *kaolinite,* resulting from the weathering of feldspar and similar materials, the principal products of

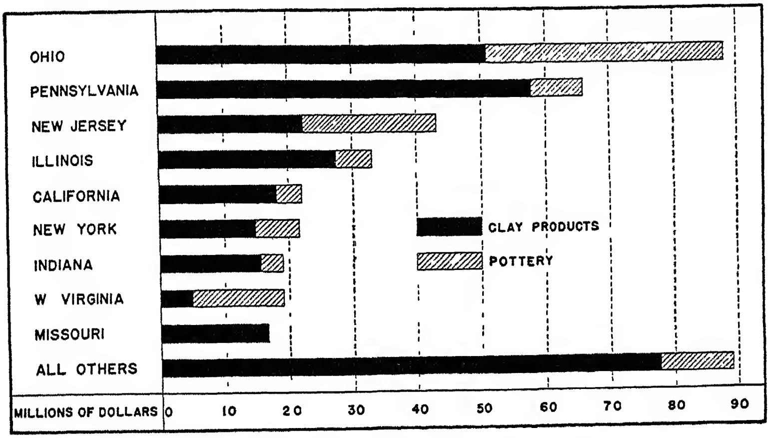


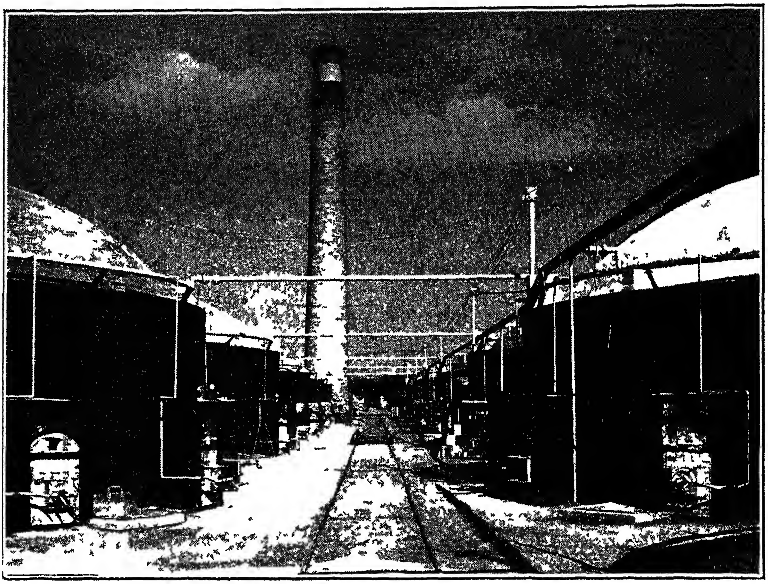
Fig 48 —Production of clay products in the principal producing states. Average 1927-1929. (Source of data *Fifteenth Census of the United States,* Bureau of the Census, Washington, D C)

which, it will be recalled, are clay and soluble salts. Under normal conditions, when weathering causes the decomposition of feldspars, the salts are carried away in solution; while the clay and some impurities, such as grains of sand or mica flakes, are left as a covering which grades down to the original unmodified rock Clays thus originating in place, because of the decomposition of the bedrock, are classified as *residual*

Transported clays result from the erosion of the land surface and the subsequent deposition of the debris in adjacent seas The coarse detritus, such as gravel and sand, is deposited along

the stream courses or near the shores of the sea; the finest particles are swept farther out where they settle down in the quiet waters, forming layers or beds, thus giving rise to the *sedimentary* clays Beds so formed are often many feet thick and of vast extent.

Clay in some form enters extensively into construction work, into a large variety of manufactures, and it is indispensable in the arts. Illustrations of names given because of particular



Courtesy, **Brick and Clay Record,** *Chicago, Illinois,*

Fig. 49.—Modern, steel jacketed brick kilns at Mason City, Iowa.

uses are pipestone, fire clay, china clay, earthenware clay, paper clay, and brick clay. The total annual production of raw clay in the United States is usually about 4,000,000 tons, reaching values of $13,000,000 to $14,000,000

The significance of the industrial uses of clay as raw material in manufactures is shown in the value of the products, which is ordinarily about $400,000,000 per year. Brick and tile manufacture has more than doubled in the United States since 1914; the value of the output in some years has exceeded $300,000,000 per year. Of brick alone, the annual output has been above

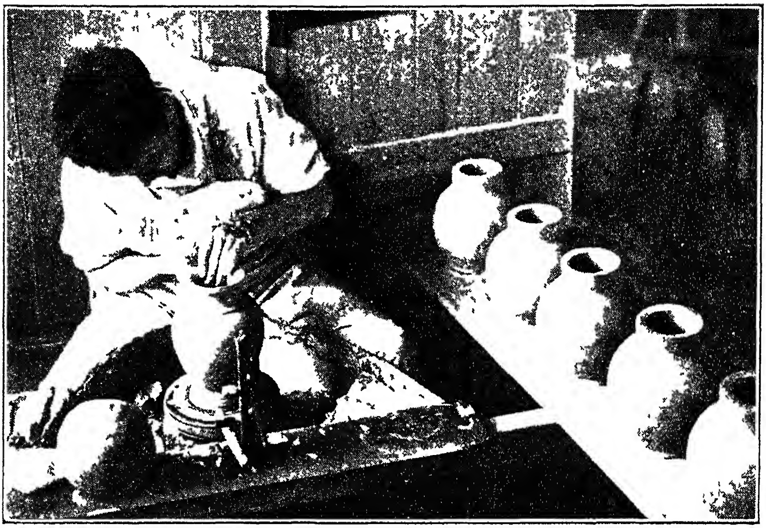
the 10,000,000,000 mark. The future of the brick and tile industries gives promise of great expansion and of increasing prosperity as wood for building purposes becomes scarcer and more expensive.

Pottery ranks second among the clay working industries of the United States The domestic production of pottery clay is not large enough to meet the demand, hence we have imports of 300,000 to 400,000 tons annually from England and northwestern Europe The imports go largely to Trenton, New Jersey, and East Liverpool, Ohio, the two greatest centers of pottery manufacture in the United States Ohio leads all the states in this industry Among the most important centers of manufacture in addition to East Liverpool may be named Akron, Zanesville, and Cincinnati The last named is particularly famous for its manufacture of distinctive American art pottery Ohio has a great variety of clays, cheap fuel, excellent transportation facilities, and great markets easily available; and these factors make for greatness On the other hand, high grade foreign clays available at minimum cost because of location at tidewater, large local supplies of coarse clays, great markets, and a dependable labor supply give New Jersey a place in the sun in the pottery industry, notwithstanding higher costs for fuel.

Clay manufactures in foreign countries.—The term *chinaware* is a recognition of the fact that manufactures of high class goods of this type originated in China Europeans, however, by revival of Chinese skill and processes and the added impetus of European art, put the industry on a commercial basis.

The modern phase of the chinaware industries was initiated by the Germans in the eighteenth century; since then world famous porcelain and pottery centers have developed in various European countries Over one hundred factories in Germany manufacture fine porcelain for export, the two best known centers being the royal factories at Meissen and Berlin. While the German exports of chinaware usually exceed those of any other country, Austria, Czechoslovakia, and Denmark all

have important porcelain and pottery industries, and each has its large following of devoted admirers During the past six centuries or more France has been Germany's principal competitor in the manufacture and sale of fine chinaware, owing largely to the high quality of the kaolin found on the flanks of the Central Plateau Limoges has become the seat of the production of porcelain wares which have won high favor in European countries and in the United States Italy for centuries has been renowned for its exports of Majolica ware, which originated in one of the Balearic Isles



Courtesy, Josiah Wedgwood and Sons, Ltd, Stoke-on-Trent, England

Fig. 50.—Manufacture of fine pottery. The "thrower" at work, modelling a vase with the aid of the potters' wheel. A pure handicraft process.

The seat of the British chinaware industry is in Staffordshire in west central England, about midway between Birmingham and Manchester There cheap coal, coarse clay, skilled labor, and excellent transportation facilities are factors which offset the disadvantage of shipping in fine clays from Cornwall and Devon in southwest England, about two hundred miles distant The greatest overseas markets for English chinaware are in Canada and Australia, but large quantities are also exported to the United States and to South American countries.

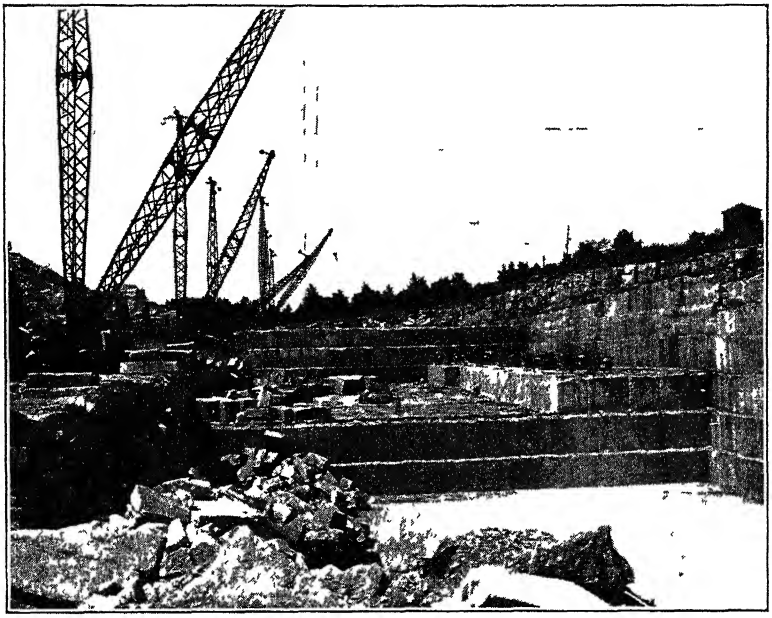
The most common secondary rocks: *3 Limestone.*—Limestone is essentially lime carbonate ($CaCo_3$), but ordinarily it contains impurities, such as clay, silt, sand, and various minerals, in varying proportions In some cases the impurities constitute less than 1 per cent, while in others they may make up nearly 50 per cent of the whole Limestones vary in color, the grays and light tans being the most common, but various other colors, such as brown, black, red, or blue, are not rare. The hardness varies with the density and the structure of the stone, some being porous and soft, others hard and dense

Principal uses of limestone.—Limestone is used most extensively as crushed rock in concrete work, particularly in pavements, foundations, and in building construction While crushed stone for concrete work accounts for a greater tonnage than does any other use, limestone has important markets for other purposes also It is used extensively as dimension material for the walls of buildings One of its most important markets is in connection with the smelting industries for use as fluxing material, the reduction of iron ore being the most important in this regard It is used in connection with sugar refining and in the manufacture of quick lime; for these purposes a relatively pure limestone is necessary It is the principal raw material in the manufacture of cement, and it has wide use as the bulky ingredient of commercial fertilizers Because of the variety of its uses, limestone may rightly be classified as one of the most important of the mineral products of the country.

Production of limestone in the United States.—The output of limestone in the United States has shown marked increase during the past decade In late years it has accounted for approximately 60 to 65 per cent of the entire commercial stone production of the United States That it is widely distributed is shown by the fact that 44 states reported commercial production in 1930, the only ones not included in the list being New Hampshire, Delaware, South Carolina, and North Dakota The states which ordinarily lead in value of output are Indiana, Pennsylvania, New York, Ohio, Michigan, and Illinois, in the

order named. Of the total quantity produced, nearly 65 per cent is in the form of crushed stone; fluxing stone ranks second, with building stone third. The amount used in agriculture to overcome acid soils is increasing rapidly and may in the future displace one of the groups now ranking ahead of it.

The most famous quarries of building limestones are located in southern Indiana in Lawrence and Monroe counties, the output being marketed commercially under the name of Bed-



Courtesy, Indiana Limestone Co, Bedford, Indiana

Fig. 51.—Bedford limestone quarry near Bedford, Indiana Note the weathered stone at the top, and the massiveness of the limestone in the quarry. Cutting machines at the right.

ford Oölitic limestone. The Indiana limestone is the most widely used natural stone for construction purposes in the United States Its markets extend from the Atlantic seaboard cities to those located near the Rocky Mountains Various reasons account for its popularity, among them its pleasing gray color, its uniform appearance on weathering, and the low cost of quarrying and milling into desired forms.

The limestone produced in Pennsylvania, New York, and Ohio is used chiefly in concrete work for foundations, street making, and pavements, and as fluxing material in smelting iron ores The high development of construction industries and the extensive road building programs which are in progress in the eastern states provide large and expanding markets for the limestone production in that section of the country

Trends in quarrying and utilization of limestone.—The de-

Courtesy, Indiana Limestone Co, Bedford, Indiana

Fig. 52 —Carving of Bedford limestone with pneumatic drills into capitals for columns.

mand for limestone is increasing in nearly all of its phases, except for dimension purposes This is particularly true of its application to the soil, in its use for pavements and road construction, and in some of the chemical industries The tendencies are definitely toward larger quarries, complete mechanization, and economy of operation It is probable that the economy of operation made possible by large scale production in favored localities will offset the costs of transportation to a large extent and thus permanently keep the total number of

quarries in operation at a lower figure than was true in the earlier stages of the industry.

The most common metamorphic rocks: *1. Gneiss*—Gneiss has the same mineral constituents as granite, being composed essentially of crystals of quartz and feldspar, and usually containing mica and hornblende as associated minerals The banded structure is its distinguishing characteristic Although gneiss occurs commonly in the eastern highlands of the United States, little use has been made of it except for building purposes and for foundation stone where available locally. Some varieties take a high polish, and these have been winning favor recently as facing slabs in the upper foundations and lower stories of business blocks

2. Mica schist—Mica schist is common in New England and in the crystalline uplands throughout eastern United States, in the Lake Superior highlands, and in large areas of eastern Canada. Upon weathering, the mica flakes which remain in the mantle rock give rise to loose and friable soil material (The only important industrial use of mica schist is as a road building material in places where it is found near the surface In many cases it is not well adapted for even this use because of the rapidity with which it disintegrates where fully exposed to weathering)

3 Quartzite—Quartzite is essentially a metamorphosed sandstone wherein the cementing material is as strong as the component sand grains, or even stronger Its colors vary as widely as do those of the sandstones, but it is always extremely hard The difficulty of quarrying quartzite and of fashioning it for use makes it costly construction material, and therefore limits its markets in spite of its recognized strength and durability Its principal use is as a building stone, although it is used to some extent for monumental purposes and was formerly quite important for cobble-stone pavements

Quartzite occurs extensively along the flanks of old land areas and along mountain uplifts In the United States one of the best known exposures of quartzite occurs near Sioux Falls, South Dakota. The most common glacial bowlders of western

Iowa, eastern Nebraska, northeastern Kansas, and northern Missouri were carried from this area into their present locations by the advances of the ice sheets.

4 *Slate.*—Slates are metamorphic rocks derived from clay or shale. They are commonly of very fine texture, and while most of them are black or dark blue by reason of their content of carbonaceous materials, slates of various other colors such as red, green, purple, or mottled are not uncommon. The value of slate depends upon its well defined planes of splitting, which render it serviceable as slabs or thin sheets for various purposes, such as table tops, blackboards, and roofing, the last named having the largest market demand in the United States.

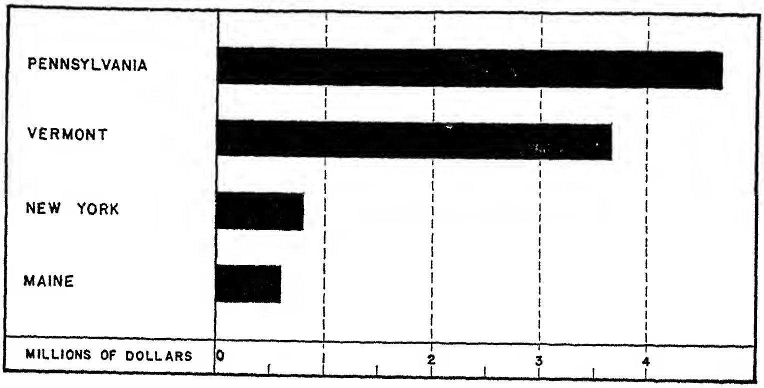


FIG. 53 —Principal slate producing states. Average 1926-1930. (Source of data *Mineral resources of the United States*, Bureau of Mines Washington, D C)

The loss in quarrying and milling slate sometimes runs as high as 60 or even 80 per cent, and this adds heavily to the cost of the finished output One of the challenging problems in the industry is the reduction of the quantity of waste or its utilization in manufactures. The present waste materials, if finely ground, have potential use in the manufacture of cement, serving the same need as the clays which are more commonly employed for that purpose

The slate production in the United States is virtually limited to the northeastern part of the country, the states leading in production being Maine, Vermont, and Pennsylvania. Farther

south, Virginia is usually credited with commercial output, but ranks far below the other three states.

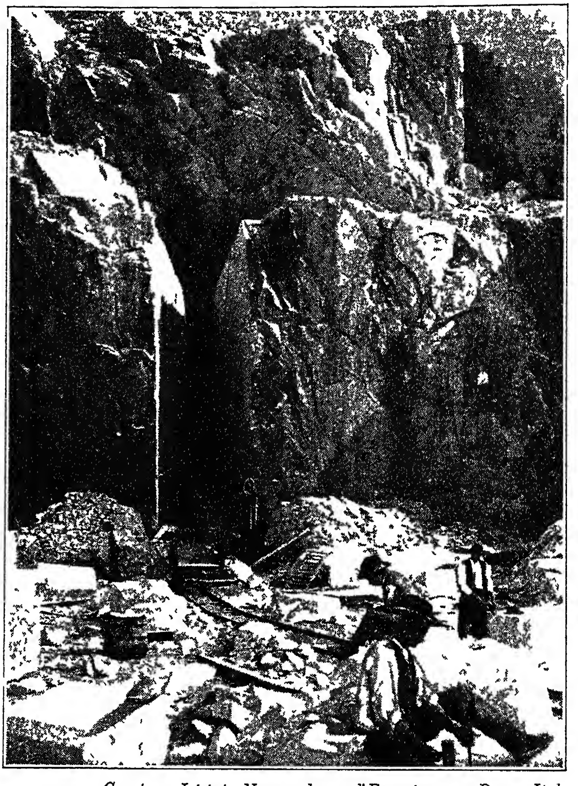
The durability of slate and its pleasing appearance account for its continued popularity for roofing purposes Nevertheless, the improvements made in artificial roofing materials and the growing competition of non-inflammable compositions constitute a real threat to any pronounced development of slate quarrying in this country. Many of the artificial roofing materials make use of some form of slate, but inasmuch as the crushed materials can be used advantageously, the result will probably be a decrease in the demand for slab or sheet slate as a definite quarry product.

5. Marble.—In value of the annual output, marble outranks slate in the United States. While, in a geological sense, marble is a metamorphic rock, the trade applies the term to any calcareous rock capable of taking a polish Like limestone, it is made up chiefly of calcium carbonate and is white when pure There are many varieties, however, resulting from impurities and from differences in structure.

Marble is used extensively for construction work, business blocks being erected of it even though it quickly shows the stain of smoke and weather The use of marble for monuments was formerly important, but it has been decreasing lately because of the inability to withstand the climatic vicissitudes which prevail in most parts of the United States. The use of marble for wainscoting and for interior decoration is increasing, owing to the attractive appearance which the finished stone presents and because of the low expense at which it may be prepared for these purposes A few varieties are well adapted for use as flooring material.

The states leading in production are Vermont, Tennessee, Georgia, and Missouri, their combined output being about 85 per cent of the nation's total Vermont is the premier marble-producing state. Its quarry center, near Rutland and Proctor on the west flank of the Green Mountains, is without a rival for size of output in this country. Marble from these localities varies from almost pure white to gray and pink, and some

varieties have intricate veins of green or brown Knoxville is in the midst of the marble producing district of Tennessee The color varies from white to mottled maroon Tennessee marble is widely used for floors and decorative interiors Georgia marble has won renown for its use in the construction of the



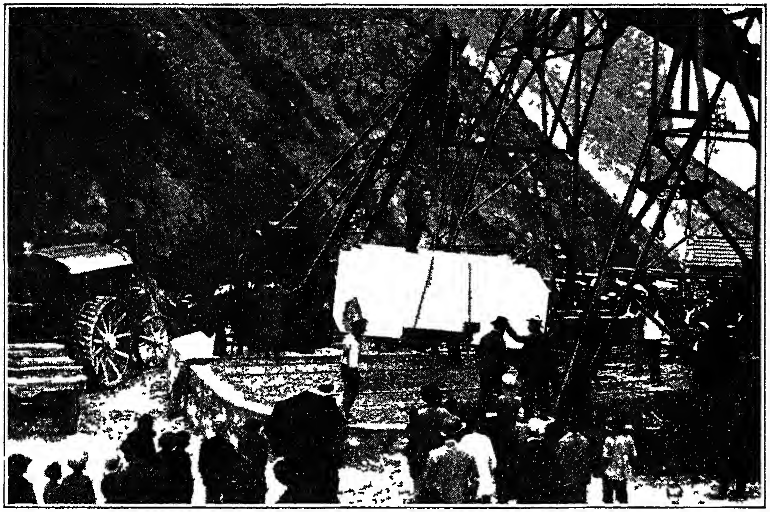
Courtesy, Istituto Nazionale per l'Esportazione, Rome, Italy

Fig. 54—Marble quarry near Carrara, Italy. Immensity of the deposit clearly shown. This is one of the many quarries in the neighborhood of Carrara.

territorial capital of Puerto Rico at San Juan Carthage marble, of Missouri, so designated by the trade for its place of output, is noted for the ability of the stone to take a fine, smooth finish; technically it is classed as a high grade of limestone

The most famous statuary marble in the world is quarried

at Carrara, Italy, a little north of the city of Pisa, on the flanks of the Apennines. These quarries have been operated for centuries and have furnished the raw material for much of the world's classic sculpture. The texture of the rock is uniformly fine grained, the color of the statuary marble is snow white, and the structure is such that flawless blocks may be obtained large enough for any use desired These qualities have given Carrara marble its world-wide fame and markets.

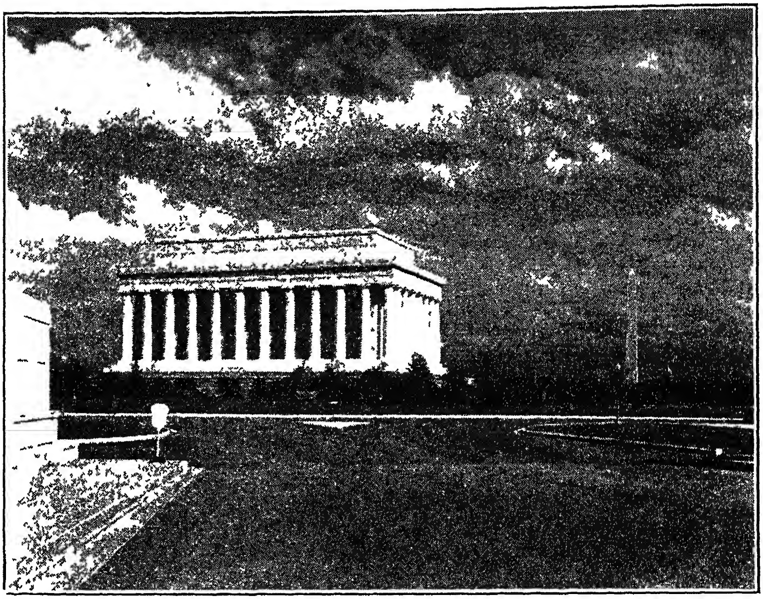


Courtesy, Istituto Nazionale per l'Esportazione, Rome, Italy

Fig 55.—Loading a block of marble near Carrara, Italy. Blocks such as these are specially prized for statuary purposes.

The demand for marble for interior finish is growing steadily. The use of marble as monumental stone is declining and will probably continue to do so, inasmuch as it is not durable enough to withstand the ravages of the weather in the middle latitudes For general construction purposes, marble seems assured of substantial markets wherever transportation charges are not so high as to limit its use in favor of lower cost competitors. In common with other materials, marble will be subject to the pulsations of style, it will undoubtedly have its periods

of high demand and of market recession, but there seems no doubt that it will always remain one of the important phases of the mineral industries of Europe and the United States.



Courtesy, Office of Public Buildings and Public Parks of the National Capital, Washington, D C

Fig. 56.—The Lincoln Memorial, constructed of marble, as seen from Arlington Memorial Bridge, Washington, D. C.

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CHAPTER VII

The Land as the Habitat of Man

WITH the limited vision imposed by his short tenure of life, man is inclined to look upon the mountains of the earth as symbols of eternity. Among some primitive peoples the mountain tops are thought to be the sites from which the spirits of the departed forever watch over their descendants. In Japan, Fujiyama symbolizes all that is old and hallowed by tradition and all that lasts while generations come and go. The cosmic order, however, recognizes no such thing as permanence, and even the most majestic mountain systems are subject to that fundamental law of nature which decrees everlasting change.

Wherever bed rock is exposed it is attacked by forces which lead to its disruption Some mountain peaks, apparently consisting of solid rock, are so thoroughly decayed at their summits that a famous Alpinist once exclaimed "Give me a crowbar and I will lower them!" Mountains—and even whole mountain systems—come and go, although at a rate so slow that only by the results produced can man grasp the significance of the forces and processes involved. In Europe the low mountains and hills of Belgium, of Brittany, and of central France once probably reached Alpine heights In the United States the Appalachians are a striking example of a mountain system which has undergone great changes in the course of its long existence.

From the point of view of economic geography it is fortunate that mountains are not the permanent features of the landscape that they are commonly believed to be. Most of the mantle rock of the earth is the result of the slow decay of mountain masses, and it is this mantle rock which gives rise to what is so essential for plant growth, the soil.

Weathering.—Rock decay induced by exposure to the elements and by the attacks of organisms is known as *weathering* This may involve only the breaking up of rock masses into smaller units, or it may involve complete changes in the composition of the constituent materials of the rock The former type of weathering, physical in its effects, is termed *disintegration;* the latter, chemical in nature, is referred to as *decomposition*

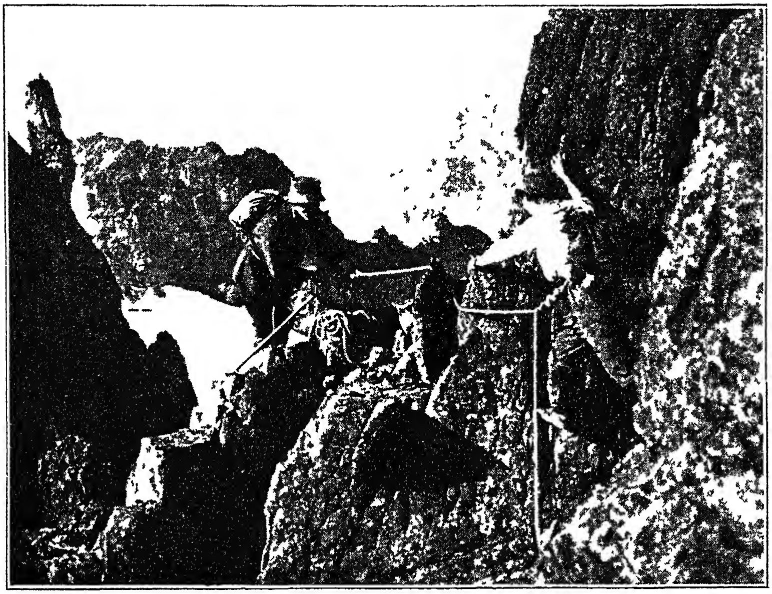
Practically all substances expand or contract with temperature changes Large bridges may expand many inches on hot summer days, and provision for such expansion must be made in their construction. Glassware is often broken because of the unequal expansion of the vessel which occurs when hot water is suddenly poured into it Fragmentation of rocks is caused by similar temperature changes

Since rock absorbs heat readily but conducts it poorly, insolation raises the surface temperatures far above that of the surrounding air wherever rock masses are exposed to the sun A few feet below such surfaces, temperature changes are slight This unequal heating leads to unequal expansion and results either in a scaling off of the outer surface or in a fragmentation of the rock, especially when the heating during the daytime is followed by rapid cooling at night The unequal expansion of the constituent minerals of many rocks also causes fragmentation This alternating expansion and contraction is an important factor in desert regions and in high mountain areas where a protective vegetation cover is absent and where there are sharp contrasts between day and night temperatures

Frost weathering.—Moisture is often present in the voids and cracks of rocks Upon freezing it expands about one eleventh of its volume In gaining this additional volume it exerts tremendous pressure Since the freezing begins on the outside, expansion must be inward Thus voids and cracks are enlarged, and the cracks penetrate deeper and deeper into the rock, paving the way for complete distintegration This type of weathering prevails where moisture is abundant, where temperature changes above and below freezing point are fre-

quent, and where there is little or no vegetation cover to protect the rock Such conditions are commonly found in and near the regions of perpetual snow in high altitudes, and in high latitudes around the polar areas Much frost weathering occurs even in middle latitudes during the winter season

Decomposition.—Chemical reactions also are persistently causing the crumbling of rock. In these processes water is the chief agent. Water, in pure state, is chemically inactive, but it



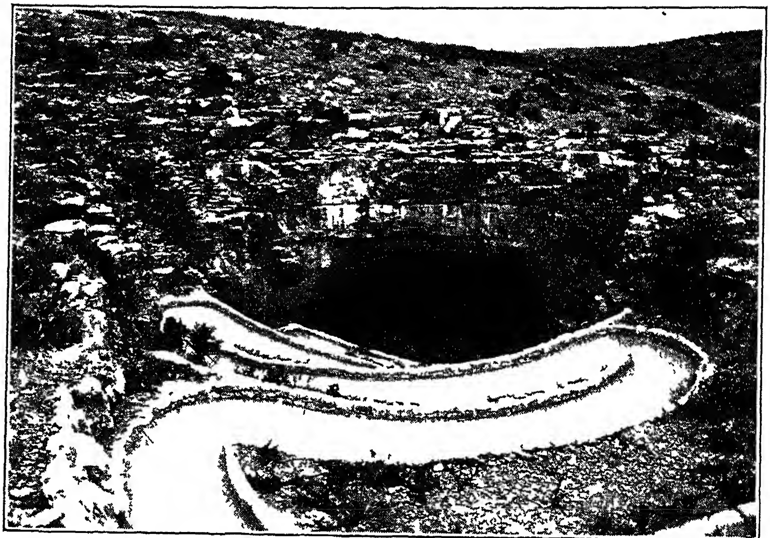
Courtesy, Swiss Federal Railroads, New York, and E Meerkaemper, Davos-Platz

Fig 57 —Rock weathering in high mountains. On the way to the top of Mt. Vadret, near Davos, Switzerland. In these high altitudes frost weathering prevails

often occurs in ionized form, and nearly always contains other matter As the raindrops descend from the clouds they gather carbon dioxide and oxygen, as they percolate through the soil, humic acids and other chemicals may be incorporated. Water, so fortified, can effect the crumbling and eventual wasting away of any rock formation.

When freezing occurs, chemical weathering practically ceases. This type of weathering is, therefore, of little importance in

high mountain or polar regions. Its effectiveness generally increases equatorward Since relatively high temperatures seem to accelerate it, chemical weathering is most active in the warm and moist tropics, where, in some places, rock is found to have weathered to depths of over a hundred feet In regions such as the Congo or the Amazon basins, outcrops of solid rock are rare and are usually found in the streambeds only. This is generally true even for areas of considerable relief and is a factor which makes exploration for minerals a difficult task in tropical re-



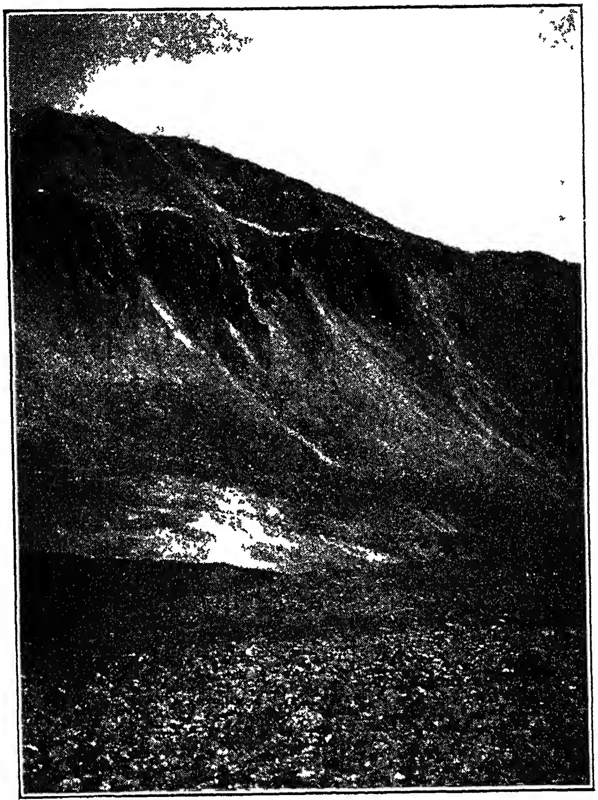
Courtesy, National Park Service, Carlsbad Caverns National Park

FIG 58.—Entrance to a limestone cave, Carlsbad Caverns, New Mexico. It illustrates the magnitude of the solvent action of ground-water upon limestone.

gions In desert areas, chemical weathering plays only a minor role because of the lack of moisture.

Some kinds of rock are easily dissolved by percolating waters, especially waters containing small amounts of carbon dioxide. Such is the case with limestone, which in some places constitutes the surface rock over quite large areas In regions of pure limestone, drainage is often partly subterranean, and there sinks and caves may abound. Even where precipitation is

high, limestone areas may suffer from drought Vegetation is likely to be scant, and such lands are usually of little agricultural value The Karst Plateau of Italy, northeast of the city of Trieste, is the classical example of an inhospitable limestone region



Courtesy, United States Geological Survey, Washington, D C Photo by E Howe

Fig. 59.—Talus slope on south side of Sheep Mountain, Colorado. Note badly weathered bedrock above the talus.

Erosion and deposition.—Weathering reduces the solid rock to large and small pieces and thus prepares it for removal by other forces In mountain regions the rock debris either rolls down, slides down, or is washed down, forming a mantle of loose material which conceals the lower parts of the slopes and thus furnishes opportunity for vegetation to obtain foothold.

Such a mantle of rock debris is referred to as *talus* Wind, ice, and flowing water can carry the loose and soluble rock debris much farther than it can be moved by the force of gravity alone Not only do these agencies transport coarse and fine rock material hundreds and sometimes thousands of miles, but even relatively solid rock can be carved and torn away by them The ultimate result of this twofold activity is the lowering of all the greater and even of the lesser elevations of the land These processes of wearing down the surface are known collectively as erosion

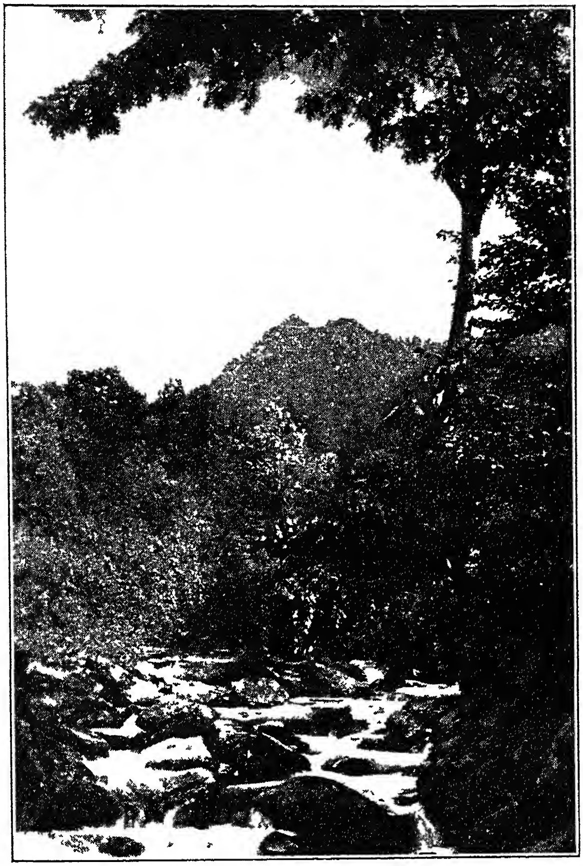
The results of erosion may be either harmful or beneficial to man's economic interests In high mountain regions, which are usually sparsely populated, erosion does relatively little damage to human interests, but in lower, hilly areas much good soil is often carried away by water, to the detriment of agriculture In southeastern United States and in some areas of the interior lowlands, soil erosion has become a serious problem

On the whole, however, erosion is more useful than harmful to man, because what rivers, glaciers, or wind transport, they must deposit somewhere. All of the valley bottoms and most of the plains areas of the world have resulted from the deposition of rock waste removed from higher slopes For example, much of the upper bedrock and mantle rock of the Great Plains of North America and of the lowlands of northwestern Europe was derived either directly or indirectly from adjacent mountain areas.

Erosion and deposition by water.—As moisture falls at various elevations, gravity promptly causes it to seek lower levels Surface run-off and ground water result, both giving rise to either intermittent or permanent streams Many small streams, intermittent as well as permanent, unite to form rivers which may drain large areas of land Most of the waters of these streams ultimately reach the sea. Drainage basins, lacking outlet to the open ocean, are said to have interior drainage

The erosive capacity of streams depends in large measure upon their velocity Those that have steep gradients are able not only to carry great loads of bowlders, gravel, sand, and finer

particles, but also to cut their beds down vigorously. In this way they not only deepen their valleys, but also cut them farther back into the uplands. At the same time the network of minor streams becomes more dense as a plant constantly grows



Courtesy, National Park Service, Great Smoky Mountains National Park

FIG 60 —Upper course of mountain stream, showing bowlders transported during flood conditions. Great Smoky Mountains National Park, Tennessee-North Carolina.

new roots, so a river grows new tributaries. Thus all the higher land finally is dissected by river valleys, and the hills and mountains in between are slowly worn away Downstream, where the gradient is gentler, the velocity of the stream decreases, and

part of the load is dropped. Here a river may build a flood-plain, often many miles wide, and where it enters the sea it usually creates a delta. River erosion and deposition must be considered the most active among the forces which model the land surface of the earth

On the whole, streams tend to assort their deposits according to size. At the foot of the mountains, bowlders, often weighing a ton or more, may be found in the stream-beds Gravel and sand are dropped farther down The finest particles, silt and clay, are carried to the lower courses and to the sea. Rock

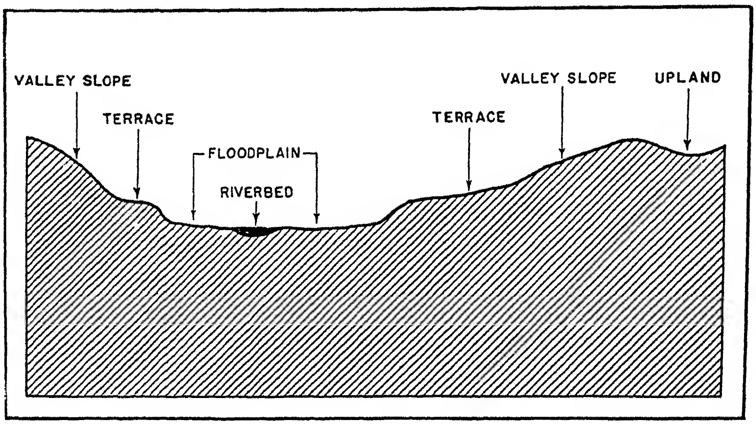


Fig. 61 —Diagram of flood plain and terraces.

debris deposited by running water is referred to as alluvial material, or *alluvium* Such material is characteristic of all flood-plains and delta regions . Also, terraces above the floodplains may consist of alluvial mantle rock

The name *floodplain* is applied to that part of a valley which is subject to flooding during times of high water. When such flooding occurs, the velocity of the river water is usually checked as it spreads laterally This in turn results in the deposition of much of the suspended fine material. Where this consists of silt, floods may contribute much to the fertility of the land, as, for example, in the Nile Valley of Egypt before the development of modern irrigation.

When a river empties into a shallow sea it usually builds a delta which eventually may project far beyond the general coast line At the entrance to the delta the river splits into various branches or distributaries which, if not restrained by man,

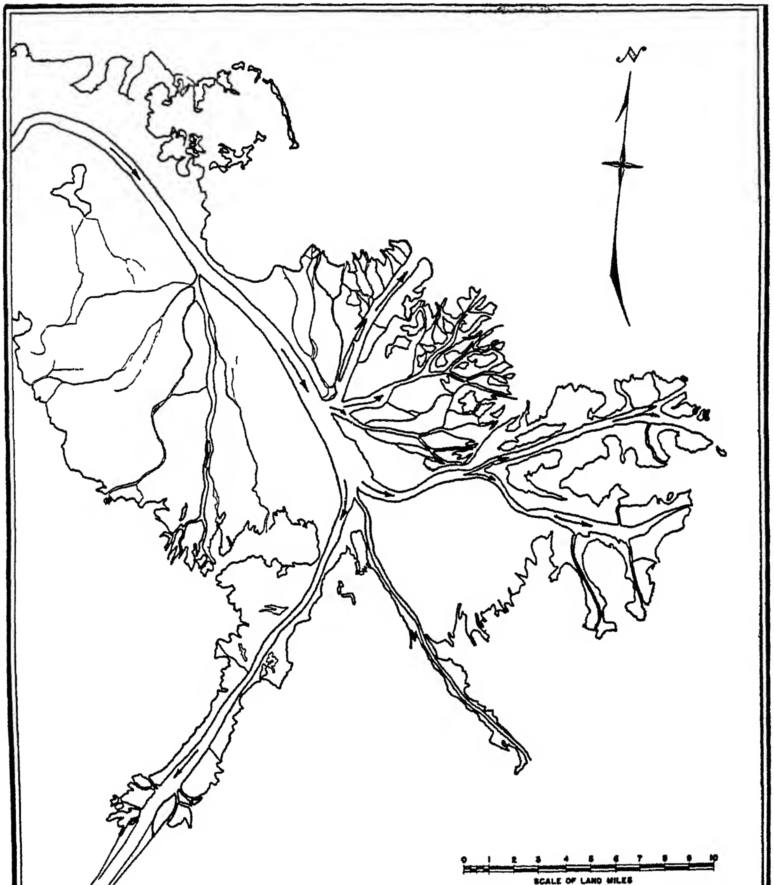


Fig. 62 —Mississippi River delta Note the numerous distributaries.

may constantly shift their positions. Much of the intervening land is swampy and in danger of being flooded during high water periods When reclaimed, however, such land may be extremely fertile. The deltas of the Rhine River in the Netherlands, of

the Red River in French Indo China, and of the Si Kiang or West River in China belong to the richest and most densely populated areas in the world.

Most streams erode or degrade in their upper courses, where gradients are steep, and deposit or aggrade in their lower courses, where gradients are gentle. The Missouri-Mississippi river system presents an excellent illustration of this general principle The headwaters of the Missouri rise in the northern Rockies After the main stream leaves the mountains it flows over the western Great Plains at an elevation of nearly a mile. Here steep gradients induce swift velocities, and active degradation of the stream channel results. Southward from the mouth of the Missouri River, the Mississippi has a very gentle gradient Hence it is constantly building up its bed It has become an aggrading stream. Near the delta, the river is often from ten to fifteen feet above the level of the main floodplain Natural levees, supplemented by man-made levees or dikes, tend to confine it to its bed But since the river continues to build up its bed by deposition, the dikes must be made higher and higher to prevent overflow; or else jetties must be constructed to force the stream into a narrower channel, thus causing sufficient increase in velocity to prevent deposition of any part of the stream load.

Erosion and deposition by wind.—Whereas water erosion is most active in humid regions, wind erosion is relatively more effective in those that are arid and semi-arid In deserts and near-deserts, vegetation is sparse, and active weathering provides much loose material Coarse sands and fine gravel are swept along the surface by strong winds, while the finer particles—such as fine sand, silt, and clay—are carried suspended in the air The sand grains propelled by the wind have an abrasive effect upon rock projections, often creating the pedestal rocks so common in some desert areas. The rock and pebble deserts of the Sahara, from which all the finer material has been removed, are the best examples of the erosive activity of the wind.

Sand dunes.—Because of their weight, sand grains are re-

peatedly dropped by the wind and taken up again. They are generally carried along the surface or within a few feet of it and thus are not transported very far in any one movement. The wind tends to pile the sand into hills, or *dunes*. In desert areas, dunes are generally devoid of vegetation, and in most instances their form and location are being actively shifted by the prevailing winds. Such dunes are often referred to as horseshoe dunes or *barchans*

The largest areas of sand dunes are found in the great desert regions of the world. the Sahara, the Arabian desert, the des-

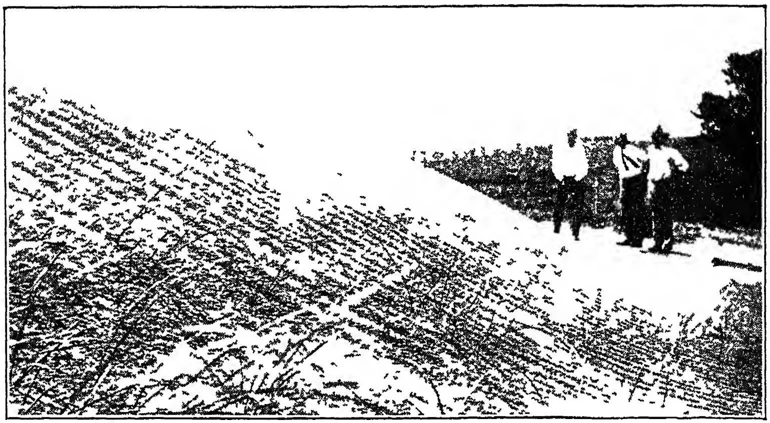


Photo by N A B

Fig. 63.—An active dune in the eastern part of the sandhill region of Nebraska. Most of the dunes are of the fixed type, i.e., they are grass covered and therefore are not actively moving under wind influence

erts of Mongolia, and of Russian and Chinese Turkestan. Extensive dune areas, now covered in varying degrees by bunch grasses, prevail in parts of the Great Plains region of the United States; the sandhills area of Nebraska being the largest and best known example Inasmuch as these have reached a high degree of stability, they are referred to as fixed dunes

Along sea and lake shores, coastal dunes are often conspicuous features Where beaches are sandy and the winds are mostly onshore, the sand grains are carried inland and piled into dunes Such dunes seem to develop around clusters of vegetation, mostly hardy grasses. In northwestern Europe, the west-

erly winds are thus responsible for the dune areas along the coasts of southwestern France, Belgium, the Netherlands, Germany, and Denmark. The Great Lakes of North America, which also lie in the westerlies, have extensive dune sand formations along their eastern shores, while on the west sides of the lakes such mantle rock is almost completely absent. Some dune areas occur also along the Pacific Coast of the United States.

Because of porosity and relative sterility, dune sand is inimical to vegetation Where a vegetation cover occurs it has only a precarious hold, since sand is mobile and in constant movement wherever exposed to the wind. Attempts to anchor dune sands have met with varying degrees of success. In a relatively humid climate, as in western Europe and parts of the United States, some kinds of grasses and even trees can be grown, but much care is necessary if plantings are to survive. Blowouts and washouts must be given immediate attention in order to prevent larger disruptions.

Loess.—Material finer than sand may be carried by the wind over considerable distances and upon deposition may give rise to extensive deposits of *loess*. Wind deposited loess ranges in fineness from clay to silt and does not show stratification; but in some places it has been reworked by water, in which case of course, it bears the earmarks of alluvial mantle rock The most striking characteristic of loess is its columnar structure, which enables it to stand vertically in cliffs, with little tendency toward sliding and slumping.

Loess deposits occur in three types of regions; namely, on the margin of desert areas, in and near areas that have been covered by continental glaciations, and adjacent to the valleys of some major streams. Various origins have been suggested to account for the loess thus found under widely different conditions; namely, that it may have been blown (1) out of desert areas, (2) out of formerly glaciated areas before vegetation had reëstablished itself, or (3) out of wide flood plains The most extensive loess regions are found in northern China, in southern Russia and Siberia, and in the central part of the Missouri-

Mississippi drainage basin. Loess deposits have given rise to some of the most fertile soils in existence. Their principal handicap from an agricultural point of view is that they occur mostly in semi-arid regions or in regions which are at least subhumid

Because of their relatively high altitude, their great thickness, which ranges up to three or four hundred feet, and their sparse vegetation cover, the loess deposits of northwestern China have been vigorously dissected by water erosion A labyrinth of large and small canyons has resulted The scarcity of timber has led to the practise of digging caves, to be used as homes by the natives, in the vertical loess walls.

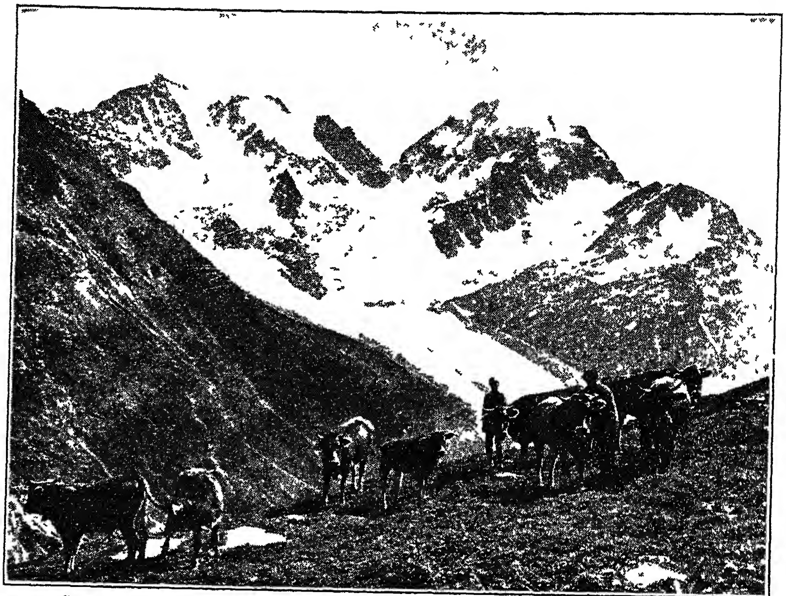
Glacial erosion and deposition.—Erosion and deposition by ice have profoundly modified much of the surface of the earth, and still continue to do so, principally in the polar regions and in the high mountain areas of the middle latitudes.

In high areas or in polar regions, snow may endure from year to year, thus giving rise to snow fields of greater or less extent As more snow falls, the accumulations become deeper and gradually harden into ice In mountain areas this ice begins to move downslope in long tongues called glaciers. The weight of the glaciers and the stones and grit embedded in their lowest layers render them very potent in scouring and gouging the surface over which they pass Many distinct features of high mountains result from this activity Among the most impressive and well known effects of the work of mountain glaciers are the U-shaped valleys

Extensive glaciation of large land masses has occurred at different times in the history of the earth. The last of these periods is commonly referred to as the Ice Age or the Glacial Period During the glacial period, huge ice sheets, probably several thousand feet in thickness, formed in the northern parts of Europe, Asia, and North America In the last named continent the ice spread from three centers the Cordilleran, in the northern Rockies, the Keewatin, west of Hudson Bay, and the Laurentian, east of Hudson Bay. The evidence shows that four or more successive ice advances occurred, each extending

varying distances into what is now the United States, and separated by long, practically ice-free periods The earlier sheets advanced farther south than did the later ones

The forward movement of these enormous masses of ice resulted in a thorough scouring of the surface, especially near their centers of origin. Mantle rock and prominent rock masses were dislodged, the rock being ground to varying degrees of fineness. Thus on the Laurentian upland in the north central



Courtesy, Swiss Federal Railroads, New York City *Photograph by F Schneider, Lucerne*

FIG. 64.—Glacier in the Alps of Switzerland Note tongue of glacier extending into valley Glacier formed from accumulation of snow from slopes in distance At the left in the distance, Bernina Peak, 12,000 feet above sea level.

and northeastern part of North America, bedrock is frequently exposed, and where mantle rock exists, it forms only a thin veneer. In this area there is little possibility of agriculture, and the forest represents the most economical use of the land. Similar conditions are found in Finland, northern Sweden, and Norway

In a wide belt near the margin of the ice covered area, de-

position prevailed over erosion; and with the melting of the ice a mantle of rock debris of varying thickness was left. The rock debris thus deposited was partly of local origin and partly derived from distant sources A large area in North America, located approximately between the Great Lakes and the Ohio and Missouri Rivers, and including most of New York and all of New England, was covered by a heavy mantle of glacial debris.

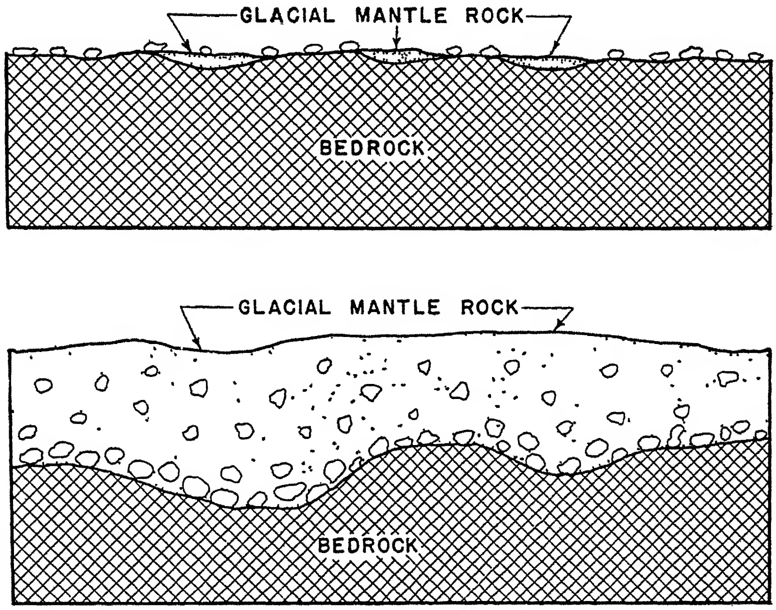


FIG. 65.—Upper diagram shows scoured glacial plain; lower diagram illustrates a glacial drift plain.

In Europe, similar material forms the surface over most of the British Isles and the northwestern part of the continent.

Glacial debris is of varied content It may be coarse or fine, dropped by the ice or by the waters which issued from the inland ice through melting. The material deposited by the ice itself is commonly referred to as *glacial drift*. This can easily be distinguished from mantle rock deposited by water or by wind While the latter are well graded, the former is unassorted and consists of a mixture of all sizes of rock fragments

Sometimes glacial drift is composed of loams, with large and

small bowlders scattered through In areas of old drift, most of the coarser materials have been broken down by weathering, and rich, easily tillable soils have been developed. In other places again the drift may be very stony and sandy, this being particularly true in areas of more recently deposited drift. Sandy glacial areas occur in northern Michigan, northern Wisconsin, and northern Minnesota From an agricultural point of view such regions must be considered as distinctly marginal. In New England the numerous bowlders made tillage difficult. The colonial farmer with unending patience picked out the stones, large and small, and piled them into mile upon mile of stone fence These stone fences are still one of the most characteristic items of the New England landscape.

Within the glaciated regions, extensive areas were covered by material washed out by the waters issuing from the ice sheet Such fluvio-glacial deposits occupy large areas in Germany, the Baltic States, and Russia. In these countries the deposits are generally sandy, and the resulting soils are poor Elsewhere large glacial lakes once existed The mantle rock deposited at the bottom of these former lakes is usually fine textured and fertile The Red River Valley of Minnesota and North Dakota, which occupies part of the bottom of glacial Lake Agassiz, is one of the best agricultural areas in the United States. As can be seen from the foregoing, regions that once were glaciated are characterized by a great variety of deposits, coarse and fine, and a great variety of soils, poor and rich

The ice also profoundly affected the topography. Especially where erosion exceeded deposition, it created numerous lakes, as in Canada or Finland Lakes abound also in the marginal areas of the youngest glaciation, as for example in Minnesota and Wisconsin. Wherever, upon its recession, the ice front rested for a longer time, much material was deposited. Such terminal and recessional moraine areas are usually hummocky and stony. Furthermore, the ice wore down many divides and ridges, filled in many small and some large pre-glacial valleys, and thus created a topography much less rugged than that which may have characterized the pre-glacial surface.

World distribution of plains, plateaus, and mountains.— The major surface features of the land are plains, plateaus, and mountains. Although these terms are not used with any great precision, they are valuable in a general description of the earth's surface.

Plains are lands of low relief and usually of low altitude. In many instances they extend inland from large bodies of water. In a few cases, as for example the Great Plains of North America, they may rise to considerable altitudes. Plains vary in surface features from extensive flat lands, only slightly dissected, to lands which are rolling and in some places quite rugged In

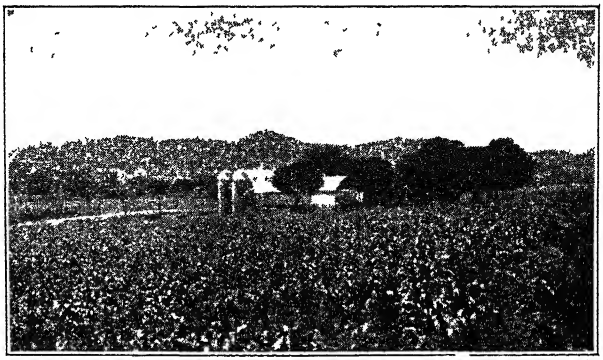


Photo by N A B

Fig. 66.—A typical plains landscape. Gently rolling topography of southern Wisconsin.

general, however, their unevenness of surface is much less pronounced than is that of either plateaus or mountains Plateaus have extensive summit areas of low or moderate relief at comparatively high altitudes; they are set off sharply from adjacent plains or mountains by steep ascents or descents. Mountains are generally areas of great relief, with small summit areas and steep slopes.

These major surface features, although often created by geologic processes, have attained their present forms as a result of erosive sculpturing by flowing water, wind, and ice. In the case of plains, especially those close to sea level, the aggrading activities of water, wind, and ice may also have contributed much

to the present aspect of the landscape. The numerous land forms thus created are of paramount importance to man, since they provide the stage on which man must carry on his economic activities—and they often greatly affect those activities.

Since the terms *plains, plateaus,* and *mountains* do not represent sharply defined conceptions, it is not possible to estimate accurately the areal extent of each one of these classes of land forms. However, both mountains and plateaus generally have

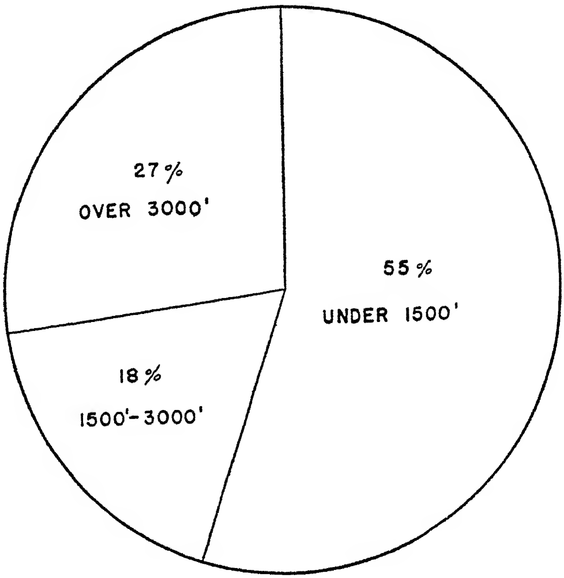


Fig. 67.—Graph to illustrate percentage of land at different altitudes

average altitudes of over 2,000, and often over 3,000, feet, while plains are usually lower Thus, the proportion of land at various altitudes above sea level gives a fair indication as to the relative areal extent of the major land forms Approximately 27 per cent of the land area has an elevation of over 3,000 feet; 18 per cent from 3,000 to 1,500 feet, and 55 per cent lies at elevations of less than 1,500 feet.

The plains of the world.—From the point of view of economic geography it is fortunate indeed that such a large percentage of the land consists of rather low plain areas. Broadly

speaking, the most favorable conditions are found there for plant and animal life and for human occupance Those areas contain the least stony and the most productive soils, while lack of great relief insures relative permanence of their soil material Road and railroad transportation encounter no major obstacles; rivers often are navigable It is no accident that by far the greatest percentage of the world's population lives in plains areas, as for example those of northwestern Europe, of southern Russia, of the United States, of India, and of China In the fertile alluvial lowlands of the Ganges, the Brahmaputra, the Hwang Ho, and the Yangtze Kiang, concentration of population is particularly great. There are, of course, notable exceptions to this general rule. Among others, the plains of northern and northeastern Canada and those of northern Asia are sparsely populated and, principally on account of severe climatic conditions, may never be able to support a dense population Other plains are unfit for habitation because of aridity, as for example those of Arabia, of the Sahara, and of Turkestan. In fact, according to a recent estimate, only about 30 per cent of the land surface is sufficiently level, warm, and moist that it may be considered capable of producing the ordinary crops of agriculture The plains are the seats of greatest industrial progress as well as of the greatest agricultural productivity.[1] On them have been built most of the cities of the world and on them are found the principal centers of cultural achievement

Mountains and plateaus.—Approximately one-third of the land area of the world lies at elevations of over 2,000 feet, and much of this area may be classified as mountainous. Some plateaus have been so severely dissected by streams that their original surfaces are represented only by the even skyline formed by the summits of the ridges In such places, as for example the rugged lands of West Virginia and Kentucky, people generally live in the narrow valleys and depend chiefly upon strips of bottom lands for their crop production Along many

[1] Fawcett, C B "The Extent of the Cultivable Land," *Geographical Journal,* Vol 76 (1930), pages 504-509

of the smaller valleys there is but little bottom land and hence the farmers try to raise crops on the steeply sloping valley sides —often with poor success because of thin soil and the rapid erosion which follows removal of nature's protective grass and forest cover Under such conditions production is poor, poverty enduring, and social progress retarded

As far as their location and continuity are concerned, the principal mountain systems of the world can be divided roughly into two major groups the Circum-Pacific and the Alpine. The Circum-Pacific group includes the mountain ranges which surround the Pacific Ocean. The Alpine group includes the mountains of southern Europe, northern Africa, and southern Asia

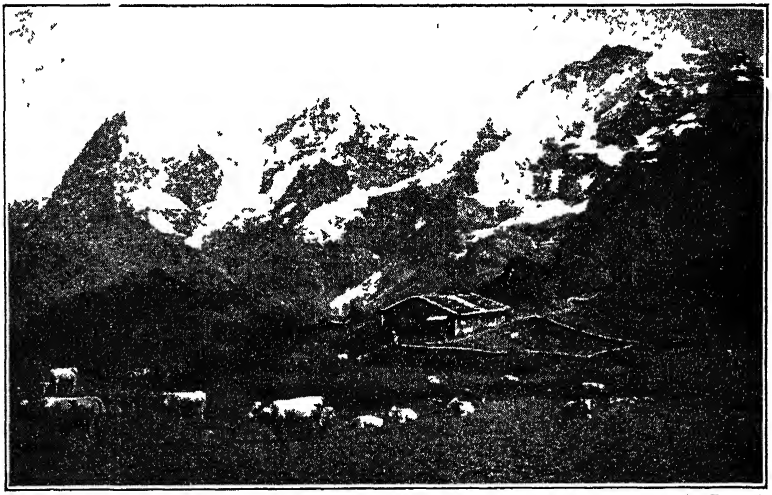
From the standpoint of economic geography, mountains may be classified into two types those which, to their very summits, are covered by forest, bush, or grassland; and those which rise above the line to which tree or grass growth is possible The latter, in many cases, are capped with permanent snow and ice fields from which glaciers descend toward the valleys On the exposed rock slopes, weathering proceeds rapidly. These mountains are characterized by sharp peaks and ridges, with steep, sometimes unscalable slopes They are usually referred to as the Alpine type of mountains, so named from the Alps Mountains in Europe In North America, the Canadian Rockies present excellent examples of truly Alpine forms Mountains which do not rise above the tree and grass lines generally show more rounded forms. Weathering proceeds more slowly, permanent ice fields and glaciers and sharp peaks are absent. The Appalachians, well known for their rounded, forested slopes and sheltered caves, are striking examples of this type of mountains

While the latter type is more friendly toward human occupancy, man finds it possible to make his living in the most rugged of mountain areas Agriculture as a rule can be practiced only on the valley floors Usually stock raising and dairying are of greater importance than is tilling of the soil In the mountains of Alpine type the animal industries often find a

valuable complement to the restricted grazing possibilities of the valleys in the pastures which lie high up on the slopes, between the forest and the region of permanent snow and ice

Courtesy, National Park Service, Great Smoky Mountains National Park.

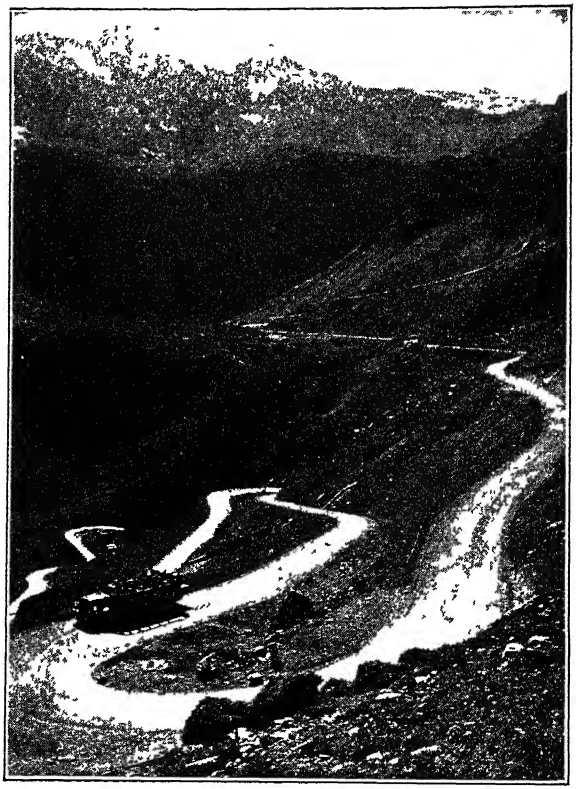
Fig 68.—Forest-clad mountains. Great Smoky Mountains, Tennessee-North Carolina.



Courtesy, Swiss Federal Railroads, New York City Photograph by Wehrli, Zuerich

Fig. 69.—Mountains of Alpine type, near Bern, Switzerland, the famous peaks Eiger, Monch, and Jungfrau. Note the grazing above the forest belt.

Under these conditions a migratory type of agriculture may develop, whereby the cattle spend the winters in the valleys and the summers in the high pastures. Sheep raising is carried on in similar manner in many areas in the Rockies and in the Sierras of western United States



Courtesy, Swiss Federal Railroads, New York Photograph by R Spring, Basel

Fig. 70 —A modern mountain road Ascent of the Klausen Pass, Switzerland. Note hairpin turns in steep ascent in foreground.

Mountain areas are likely to be centers of mining. Many mountain areas consist principally of igneous and metamorphic rocks which may be rich in ores of copper, gold, silver, lead, zinc, and other metals. In the United States mining is the principal pursuit in many districts of the Rocky Mountains

Possibly the principal economic role of mountains is of a

negative character. Mountains form not only climatic barriers. but also barriers to transportation, and thus to commercial intercourse. For centuries China has been practically isolated from the western world by the mountain masses of interior Asia. In America the Appalachians were long a barrier which hindered expansion of the Colonies to the west.

Transportation across mountain regions necessarily follows the relatively low passages, known as passes, which usually are comparatively few in number Construction of roads across

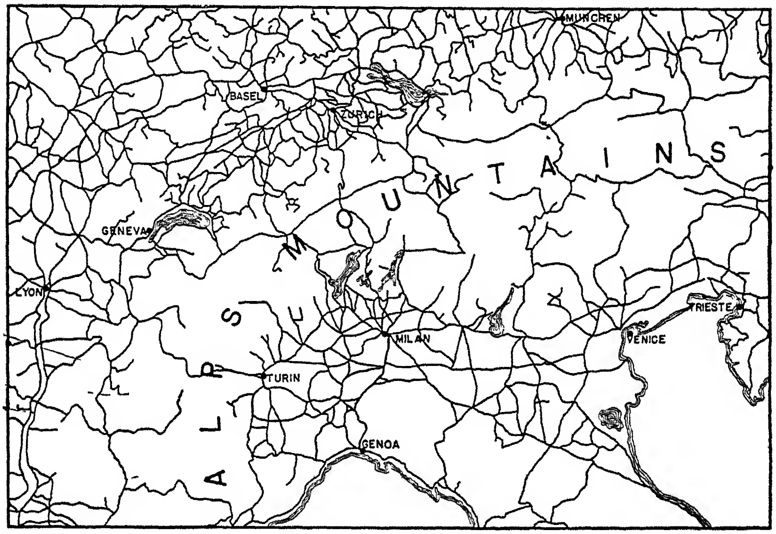


Fig. 71 —Railroads of the Alps and neighboring territories. Barrier effect of the high mountains clearly shown.

such passes is often difficult, and in many cases the passes are blocked by heavy snow during the winter season. With the advance of technical knowledge, man has learned to build better roads and has become able to pierce mountain ranges by means of tunnels which are sometimes many miles in length. Construction of such tunnels is, however, an arduous and costly undertaking Thus, mountain ranges will always remain obstacles to commercial intercourse.

Although mountains are not of great direct economic value, we should not forget that, as a result of their height, they re-

ceive large amounts of precipitation in the form either of snow or of rain, and that this moisture is often indispensable to the plains below them

Plateaus may vary greatly in elevation. High plateaus, as that of Tibet, are inimical to human occupance In warm, tropical regions, however, plateaus of moderate elevation offer the best sites for human activities The high plateaus of Kenya, Tanganyika, South Africa, and Abyssinia have a healthy climate which facilitates agricultural development. The plateaus of southern Brazil are the most densely populated part of the entire country The same is true of Colombia, where the plateau of Bogota is the seat of the most densely populated part of the country and is well known for its diversified agriculture, its industrial activity, and its high degree of cultural progress.

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CHAPTER VIII

Minerals of Direct Economic Use

THE minerals discussed in Chapter V were those which are important chiefly because of their occurrence as rock constituents. Their importance in this respect outranks their economic significance, because they impart to each of the common rocks their unique properties or qualities. For example, although quartz has a variety of uses, such as for glass making, in the manufacture of refractory vessels and optical instruments, its major significance is its occurrence in many kinds of bedrock and in most kinds of mantle rock and soil As a rock constituent it usually occurs as fine grains which, because of their resistance to decomposition, have significant effects upon the texture and porosity of the rocks and soils of which they form a part Feldspar may be cited as another illustration of this same general principle. Although it has important uses in the manufacture of china and porcelain ware, there is greater significance attached to its role as rock constituent and to the products which result from the weathering of any rock of which it is a part The same could be said of the other minerals studied, although the commercial significance of some is ranked somewhat higher relatively than is the case with quartz and feldspar

In this chapter we shall discuss the minerals which have direct economic importance. While they are also important rock constituents, their greatest value to man lies in their industrial uses without any necessity of conversion into other products through intricate smelting or reducing processes. There are many minerals of this kind, but we shall limit our study to those which occupy the most important places in the industrial scheme, namely, sulphur, salt, and those which make up the bulk of commercial fertilizers.

SULPHUR

Sulphur is of widespread distribution among igneous rocks, particularly lavas, but it usually occurs in such small quantities and in such association with other minerals that economic extraction is impossible. Commercial production therefore is restricted to a few areas where large bodies have been discovered under conditions favorable for exploitation While some sulphur has been produced in a number of places —particularly in Japan, Spain, and Mexico—most of the world's output is now supplied by the island of Sicily and by the Gulf Coast of Texas

Uses of sulphur.—The most important uses of sulphur are in the manufacture of sulphuric acid and in paper making For these purposes sulphur is indispensable It is also used in the manufacture of matches, gunpowder, fireworks, and insecticides, and is extensively used for medicinal purposes and for vulcanizing India rubber Recent discoveries have materially increased its demand for use in technical industries Sulphur also has an increasing use in timber preservation because of the ease with which it may be liquified and thus be forced into the pore-spaces of the wood With increasing costs of lumber there will be greater demand for preservation, and in this connection, notwithstanding the more general application of coal-tar preservatives, the use of sulphur will probably increase

Production of sulphur.—World production of sulphur has been increasing steadily during the past quarter of a century. In the period 1911-1915 the average annual world production was only about 800,000 metric tons, whereas in the years 1926-1930 the average exceeded 2,500,000 metric tons per year, an increase of about 200 per cent in 15 years Italy was for many years the world's leading sulphur producing country. In 1911, for instance, the Italian production accounted for 54 per cent of the total, whereas the United States held second place with only 21 per cent Since 1916, the United States has been in first place, and in recent years has produced more than 85 per cent of the world's total; Italy in second place has furnished

only 12 to 15 per cent The only other countries having any important production of sulphur are Spain and Japan

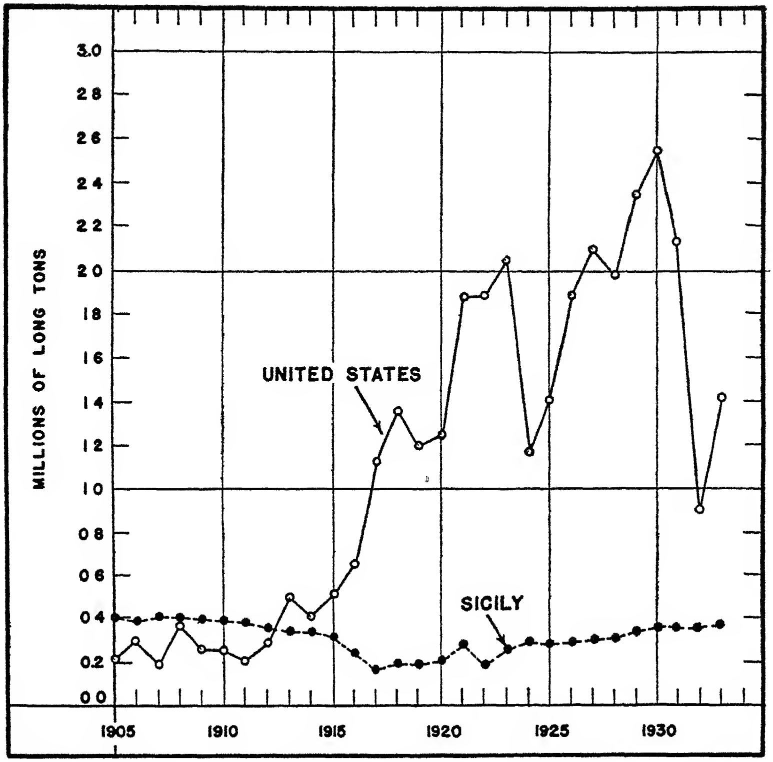
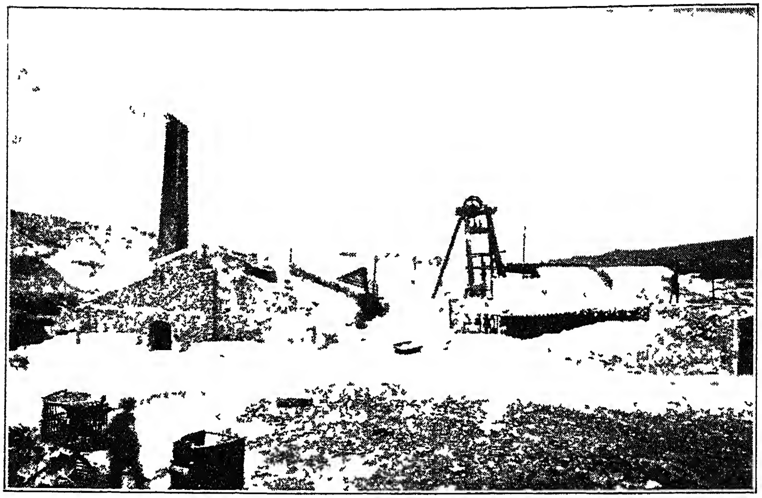


FIG 72.—Trend of Sulphur production in the United States and Sicily. (Source of data *Mineral Resources of the United States*, Bureau of Mines, Washington, D C)

Sulphur in Italy.—The island of Sicily is Italy's most important sulphur producing center. For many years it was the world's foremost source of raw sulphur The Italian industry has been hard hit by the development of the deposits found in the United States since 1908 and the resulting competition that the American output has furnished in the world's markets. There seems little chance that Sicily will again assume world leadership, but with improved methods of production and assured access to important foreign markets, the output may be stabilized at about 250,000 to 300,000 metric tons. The prin-

cipal foreign markets for the Italian sulphur are in the Mediterranean lands, central Europe, Russia, India, and the East Indies.



Courtesy, Italian Tourist Information Office, New York

Fig. 73.—Sulphur mine in Sicily, Italy.

Sulphur in the United States.—The production of sulphur in the United States ordinarily exceeds 2,000,000 tons per year, more than 99 per cent of which is represented by the output of companies operating in the Gulf Coast deposits of Texas and Louisiana. For a number of years Louisiana was in the lead Because of the low cost of exploitation of the large deposits found in the coastal plain southwest of Galveston, Texas has been producing more than 75 per cent of the country's total in recent years.

The foreign trade in sulphur has been mounting rapidly during the past decade. The United States ordinarily exports more than 25 per cent of its output The leading markets are in Canada, Germany, France, Netherlands, the United Kingdom, and Australia Owing to extensive development of the chemical and electrical industries, Germany has lately become one of the foremost foreign customers for American sulphur

Because of extensive proven reserves, Texas and Louisiana

is, by pumping warm water down to the bed of rock salt and there churning it about by especially devised agitating methods and then pumping up the brine The known deposits of rock salt vary in thickness from a few inches to over two thousand feet.

Uses of salt.—The greatest demand for salt is for domestic purposes. It is the only mineral which enters directly into the diet of man and beast on a large scale and which is indispensable to their existence Primitive people show great ingenuity in

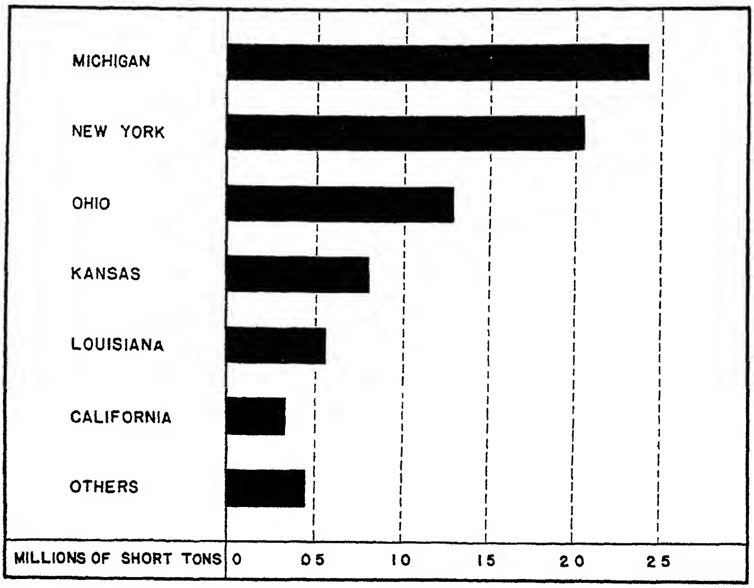


Fig. 75 —Principal salt producing states. Average 1926-1930 (Source of Data *Mineral Resources of the United States*, Bureau of Mines, Washington, D C)

their means of securing salt supplies It is claimed that the practice of eating earth, reported of some tribes, may be attributed to the need for salt Among some peoples, salt takes the place of money. Places where salt could be obtained were declared neutral ground by many of the Indian tribes of the Great Plains Tribes otherwise hostile would meet at such places and gather their salt in friendly rivalry, whereas meeting elsewhere would lead to deadly combat This practice was a direct tribute to the necessity of salt in man's diet.

Because of the universal need for salt, some countries have made its output and trade a national monopoly and thereby have used it as a medium of taxation for revenue This is a practice not uncommon among countries which have colonies in tropical lands and where the collection of property taxes from impoverished natives is quite difficult

Salt is valuable because it serves as a preservative of foods, especially of meats, and hence is of prime importance in the operation of packing plants and dairies Creameries use large quantities in the manufacture of butter Other uses for salt are in connection with the chemical industries and in the treatment of gold ores The foremost demand for salt, however, is its use for domestic purposes—that is, its consumption by people and animals.

Distribution of salt production in the United States.—The production of salt in the United States has shown a slight upward trend during the past decade Normal production is about 7,500,000 tons per year, most of which is produced in Michigan, New York, Ohio, and Kansas, in the order named. These four states generally account for 98 per cent or more of all the salt produced in the United States.

COMMERCIAL MINERAL FERTILIZERS

Phosphates, nitrates, and potash are the chief ingredients of most of the various mixtures referred to as commercial mineral fertilizers. In many regions of the world the application of mineral fertilizers is necessary for successful agriculture. The great milestones in agricultural progress may be said to consist of the initiation of the four following improvements in methods of production (1) the introduction of grasses, especially clovers and other legumes into the crop system; (2) the plowing under of green crops like peas, clovers, and other legumes, all broadly included under the general term of green manures; (3) the utilization of root crops, such as mangels, turnips, and beets, thereby breaking up the practice of continued grain farming on the same plot of ground, and at the same time im-

proving the physical condition of the soil, and (4) the scientific application of mineral fertilizers The last named practice became general in many agricultural districts as a result of the chemical study of soils, a development which has characterized the period since 1860.

During the Middle Ages and later, students of population and food supply expressed alarm because of the declining productivity of the soil Lands in the Mediterranean countries were producing only four to six bushels of grain per acre, and productivity was steadily declining on lands long in use The lower Nile Valley was an exception because of its recurrent floods and the attendant replenishment of soil fertility; these caused productivity to remain high and made of that region a rich granary greatly desired by the various Mediterranean powers In Britain and Belgium from 10 to 12 bushels of wheat or rye was considered to be a good yield. The farmers of the times found it increasingly difficult to maintain the crop yields of the land, and this, in the face of increasing population, gave rise to a growing fear of famine. Production was being maintained largely by clearing new lands and making use of virgin soils; as the areas of such lands were rapidly declining, serious students began to fear that the day of exhaustion of the soil was approaching and that the time would soon come when the population of the world would be reduced by starvation. Under these conditions, there is little wonder that people began to think of the world as growing old The idea became so firmly implanted into human consciousness that to recognize any other point of view seemed out of the question. The earth has, of course, existed many millions of years, and man has lived upon it many thousands of years, but neither of these facts are evidences of an old world *Old* connotes waning power, lessened productivity. In this sense the world has actually become younger since the Middle Ages, because man has turned retreat into advance. Instead of waning, the world is growing stronger; yields are increasing instead of decreasing.

Conditions of productivity of the soil have been radically changed during the past few centuries. England now averages

30 bushels of wheat to the acre, and many farmers produce crops of 40 to 50 bushels per acre year after year The Dane expects to produce 40 bushels per acre, although his land has been farmed for many generations Some of the finest wheat

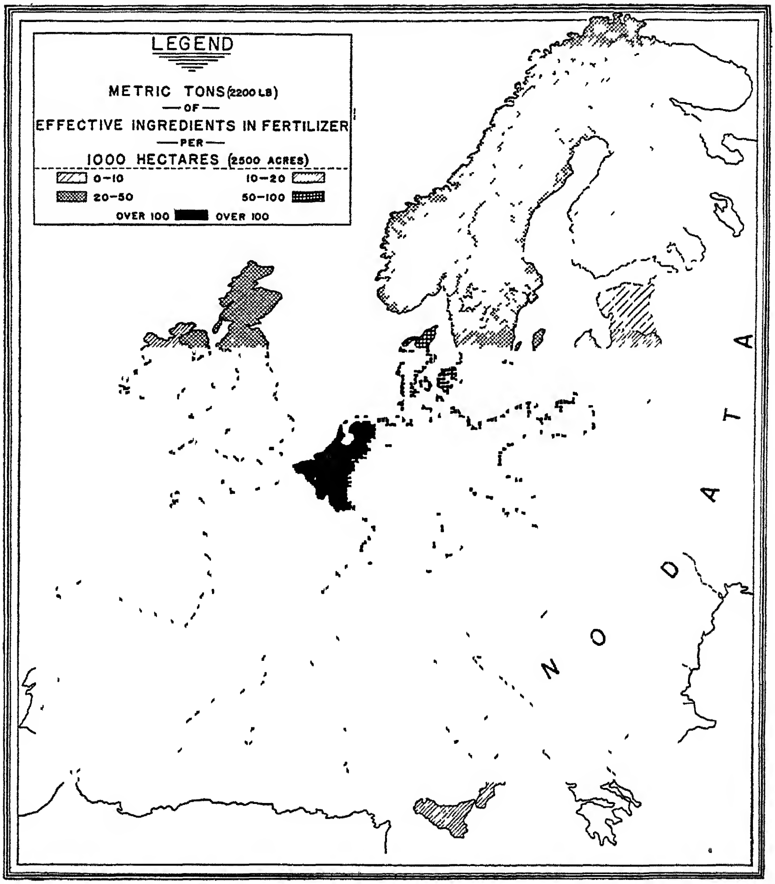


Fig. 76.—Consumption of commercial fertilizer in European countries.

yields of the world may be seen in southern Sweden, where the soil has been tilled for centuries. The specter of want has been routed. The world now gives promise not only of greater production, but also of more prolonged production than seemed possible to students in earlier times. The achievement of agricultural science has given us a world of renewed youth in which

to live. This accomplishment is, of course, the result of several factors, such as improved methods of tillage, crop adaptation, introduction of new varieties; but in the whole scheme the use of mineral fertilizers has played an important part.

Commercial fertilizers in the United States.—The fertilizer industry has become one of the major industries of the country and one of growing importance to the success of agriculture in many sections. The output of American fertilizer plants has increased from less than 3,000,000 tons in 1899 to about 8,000,000 tons at present, an increase of 172 per cent. The industry,

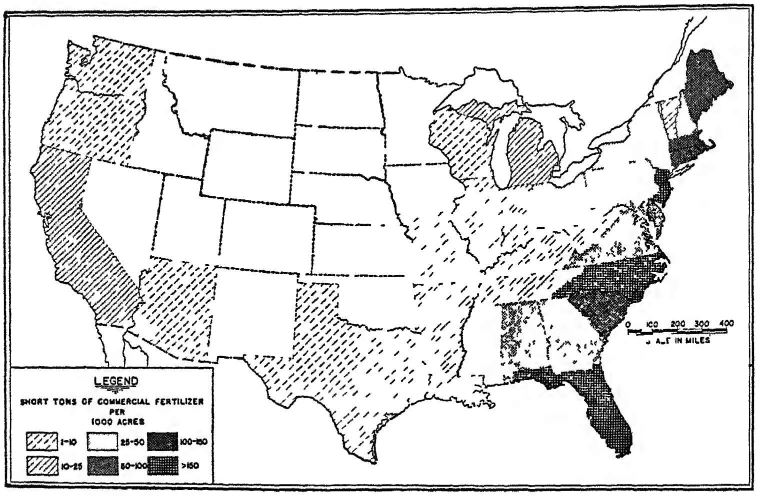


Fig. 77.—Consumption of commercial fertilizer in the United States.

with respect to both production and consumption of fertilizers, is concentrated in the northeastern and southeastern parts of the country. These areas, comprising about one-fifth of the total land area of the nation and about the same proportion of its farm acreage, contain over 80 per cent of the fertilizer plants, produce 85 per cent of the output, and account for over 85 per cent of the consumption.

The fertilizer industry of the United States is dependent upon foreign countries for much of its raw material The imports of fertilizer and fertilizer materials aggregate from 2,500,000 tons to 3,000,000 tons per year. In recent years Chile and

Germany together have supplied 70 per cent of the total imports Nearly 90 per cent of the imports enter the United States through the Atlantic and Gulf ports nearest the consuming areas Quite naturally, most of the plants which prepare the fertilizers are located where such materials are most needed—namely, in the eastern states. There the population is dense, much of the land has been farmed a long time, rainfall is heaviest, and the soils have been leached most severely. All of these factors combine to make that section predominant as a market center for commercial fertilizers

In the eastern part of the United States and in most countries of the old world, successful agriculture depends upon the application of various plant foods to the soil These may be applied separately, but experience has proven that better results are obtained when they are mixed in such proportions as the particular soils may need According to the United States Department of Agriculture, about 70 per cent of the fertilizer used by the farmers of this country is purchased in ready mixed form, commonly known as commercial fertilizers; the remaining 30 per cent consists of materials which may be applied unmixed or used in preparing home-mixed fertilizers. Fertilizer grades are usually designated by numerical symbols which refer to the three essential ingredients; namely, phosphates, nitrates, and potash. Thus, a fertilizer of "8-3-4" grade specifies one which has a plant food content of eight units of phosphates, three units of nitrates, and four units of potash A ton of such fertilizer contains 160 pounds of phosphates, 60 pounds of nitrates, and 80 pounds of potash, a total of 300 pounds of actual plant food per ton The remaining ingredients in a ton of commercial fertilizer act as carriers and generally consist of materials which have beneficial action on the soil Some form of lime is ordinarily the chief constituent of this carrier material

Principal kinds of commercial fertilizers: *1. Phosphate rock*—Rock phosphates are chiefly phosphates of lime, and, although their chief value as fertilizers depends on their phosphorous content, the soils which need phosphorous are gen-

erally also in need of lime In addition to their importance as fertilizers, the phosphates constitute the raw material for a number of industrial products. The industrial uses have increased greatly in the past decade, and all indications point to even greater expansion in the immediate future.

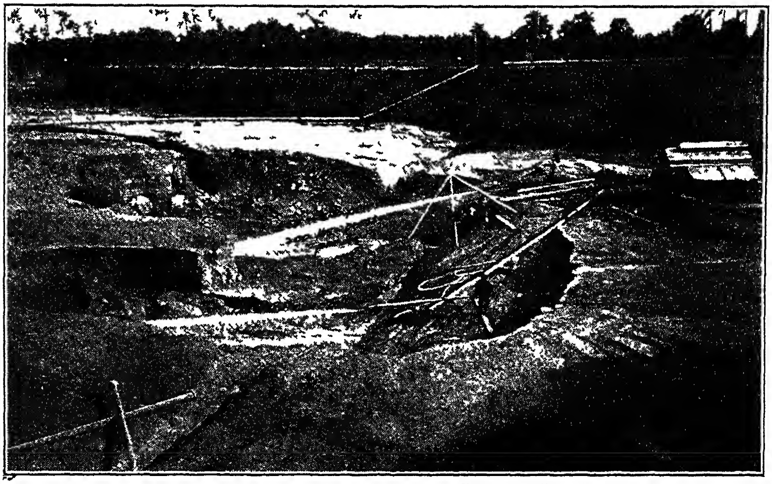
The United States has been the foremost producer of phosphates during the past three decades, but northern Africa, taken as a unit, has now taken first place, although the United States still ranks first among the countries of the world in annual output. Tunis ranks second in production, followed by Morocco and Algeria. The four countries named account for more than 85 per cent of the world production North Africa ordinarily may be expected to produce about 50 per cent of the world's output, the United States about 35 per cent, while the remaining percentage is scattered among 20 or more other countries.

Phosphate rock in the United States.—While phosphate rock is known to exist in a number of states, the commercial production is limited to a few. Florida and Tennessee are the two leading states, while smaller quantities are produced in some of the western states, especially Montana and Idaho During the decade following 1920 the average annual output of rock phosphate in the United States exceeded 3,000,000 long tons, Florida alone accounting for over 83 per cent of this quantity Phosphate production in Florida is favored by low expense of mining, by huge reserves, and by nearness to markets and to ocean transportation The rock phosphate occurs in a thick bed overlain by comparatively thin overburden which is easily removed by steam shovel methods. The rock is soft and therefore can be mined by hydraulic means. Water is plentiful. This situation makes for low costs of mining, which, together with location near seaboard, put the industry in a particularly favorable position for economical operation in all its phases.

The increasing importance of intensive agriculture in the Pacific Coast states has given rise to important local markets for phosphates, and this has caused some increase in produc-

tion in the Rocky Mountain area In Idaho and Montana have been discovered large reserves of phosphate rock which give assurance of unfailing supplies for many decades to come. That production will continue seems probable, but there is no likelihood that it will reach proportions comparable with that of Florida.

Large quantities of phosphate rock are exported by the United States every year. During the five-year period ending in 1930, the average annual exports exceeded 900,000 long tons; this was about 25 per cent of the total production. Europe is,



Courtesy, Coronet Phosphate Company

Fig. 78.—Phosphate mine in Florida. Hydraulic methods are used. Note overburden, phosphate matrix, and bedrock.

and consistently has been, the most important customer, taking two to three times as much as the rest of the world. Germany, Italy, and the Netherlands rank as the leading European markets for American phosphates. In recent years Japan has developed into one of our greatest foreign markets. The dense population and the necessity of high yields of crops make it probable that the Japanese demand will continue to be high. Canada and Cuba are also important, the former characterized by a gradually increasing demand for phosphate, the latter by

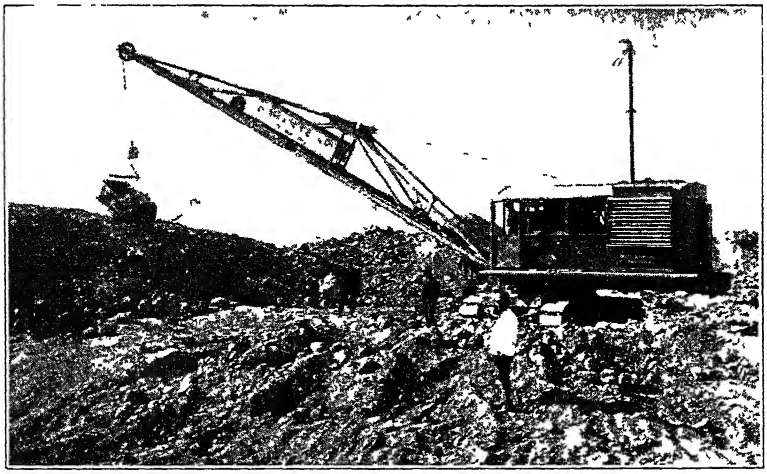
wide fluctuations varying with changing economic and political conditions.

All indications point to the continued importance of the American export trade in phosphate rock The reserves in Florida are great, mining costs are low, and the fertilizer and chemical industries of northwestern Europe and Japan are expanding rapidly Competition from northern Africa, however, is likely to increase, and supplies from that source may be expected to reduce American sales in the Mediterranean lands and in southern Asia.

Principal kinds of commercial fertilizers: *2 Nitrates*—Nitrogen is the most expensive of the fertilizer minerals It may be obtained from many sources, the supply in nature being inexhaustible, but most sources involve heavy expenses in extracting and converting it into forms fit for industrial or plant use Indirect sources of nitrogen have long been important; for example, dried blood, tankage, and unusable materials from packing plants. · Fish scraps, dried fish, dried crabs, and other fish refuse all have important use in some places The use of fish as fertilizer is still practiced rather extensively in Norway and parts of Japan. This is a practice of long standing in the New World as well as in the Old It is claimed that the Indians showed the early settlers of Plymouth, Massachusetts, how to produce Indian corn by placing a fish in every hill of seed. The Indians of Virginia followed the same practice, and it is generally believed that the commendable yields produced near the Atlantic seaboard under the primitive methods of Indian agriculture were due largely to the use of fish in the enrichment of the soil.

Mineral nitrate is a product of the desert Small quantities have been found and produced in Death Valley, California, and in other desert areas in the southwestern portion of the United States, but from a commercial point of view, Chile has long been the world's only important source of supply. The desert of northern Chile, high-lying and rainless, located between the lofty peaks of the Andes and the Pacific coast, constitutes the world's greatest store of mineral nitrates These

deposits of soluble nitrate of soda have been slowly concentrated there through the ages, and remain a testimonial to the economic significance of the desert; a decade or two of moderate rains would remove them all. Mining methods are relatively simple The cover of the few feet of non-nitrogen bearing materials is removed as strippings by steam shovel methods. Below this overburden the nitrate ore—known as *caliche*—is relatively soft, and necessitates only a moderate amount of loosening by explosives The caliche is then loaded by steam shovels into cars and hauled to the refining plants where it is



Courtesy, Chilean Nitrate Educational Bureau, New York

Fig. 79.—Shoveling caliche in the Atacama Desert of Chile.

leached by water; the nitrates go into solution and are thus separated from the insoluble earthy material. These solutions are then evaporated to dryness and the nitrates precipitated as salts in a manner similar to that which is employed in precipitating sugar from cane or sugar beet juice In the process of refining, iodine is obtained as a valuable by-product.

Historical sketch of the development of Chilean nitrate.—It is claimed that early in the nineteenth century, a party of Indians, traveling across the wastes of what is now northern Chile, discovered a rock that had the property of feeding the flames of the campfire. Suspecting the presence of evil spirits,

they hastened to consult one of their priests, seeking from that traditional source of wisdom the interpretation of the strange phenomenon which they had witnessed. After examination, the rock was tossed into the garden, where it later attracted attention because the plants growing near it flourished amazingly in contrast with the meagre growth shown by plants in other parts of the garden. In that manner the presence of plant foods in the rock was discovered, and the "fire rock" became a thing of promise. This story of the Indians and the priest illustrates the beginning of what became an industry of immense proportions, with its products shipped to all parts of the earth.

The Chilean pampa is devoid of life except in those parts where the nitrate industry hums and where railroads, carrying foods and industrial supplies to the workers in the parched inland regions, bring back the refined products to the coast The country is desolate Rain is unknown except at rare intervals. Wild life is almost non-existent, and it is said that even the fleas and other "undesirable passengers" prefer the mild sea level climate of the coastal towns When their hosts, the *rotos* (the working men of the nitrate pampa), leave the ports to go back to duty in the high-lying nitrate fields, it is natural to suppose that many of the vermin go with them. Rumor has it, however, that with increasing elevation and aridity the pests become uneasy, and that when the train reaches the first stop in the steep climb, they get off, cross the line to the down platform, and return coastward with those rotos who are on their way to a lower and more congenial environment!

Commercial exploitation of the Chilean deposits began in 1830, a small amount of nitrates being exported in that year. Development grew slowly, but in the late seventies large production had been attained. The deposits had been developed throughout this period largely by Chileans, although the nitrate fields were in lands then belonging to Peru and Bolivia The War of 1879-1882, between Chile on one side and Peru and Bolivia on the other, ended in a decided victory for Chile; as a result, Bolivia was forced back from the sea, and Peru had to

give up her nitrate lands Chile became master of the world's greatest nitrate deposits, receiving what proved to become a colossal indemnity.

Chile, owing to her nitrate, has long been in an enviable position, able to supply almost unlimited quantities of a material essential in the prosecution of war and of vast importance to agricultural and commercial development in times of peace. The nitrate industry of Chile ordinarily employs over 100,000 men. It has transformed a barren desert into a region of industrial activity. It has stimulated the growth of coastal towns and railroad facilities, and through export taxes has contributed much of the nation's income The total sales since

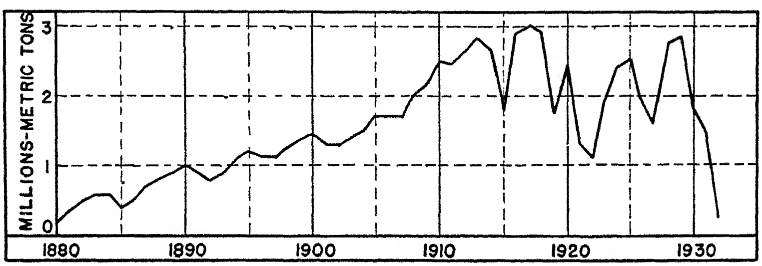


Fig. 80 —Nitrate exports of Chile.

1880 have exceeded 80,000,000 tons, worth nearly $5,000,000,-000. The export tax has in the past contributed as much as 80 per cent of the nation's revenue Taltal, Antofagasta, Tocopilla, and Iquique are the best-known nitrate shipping ports. The last named has been called the nitrate capital of the world Much of this industrial glory is facing decline because of the expanding output of synthetic nitrogen in the United States and Europe.

International trade.—The average exports of nitrate from Chile since 1920 have been about 2,000,000 metric tons per year, of which approximately 40 per cent has been sold to consumers in the United States The remainder has been sold mostly in Europe and Egypt, although minor quantities are exported each year to Asia and Africa

For a time it was felt that the processes involving nitrogen

fixation from the air would completely displace the Chilean product because of the mounting costs as the richest deposits were becoming exhausted But improved methods of mining and refining have succeeded in lowering production costs, so that Chile may continue as an important producer of nitrates for years to come Owing, however, to the rapid development of processes of making artificial nitrates, Chile has lost her monopolistic position in the world's nitrate industry Whereas in 1885 Chile produced nearly 85 per cent of the world's nitrogen requirements, she has recently been reduced to a position of meeting less than 25 per cent of the world's demand Germany now makes compounds involving more nitrogen equivalents than does the entire Chilean output, in some years more than doubling it. Future trends will probably show the growing importance of artificially produced nitrates, and thus reduce still further the relative position of Chile in the industry. But even though preëminence may be lost, all indications point to the continued prominence of Chilean nitrates in the world markets.

Principal kinds of commercial fertilizers: *3. Potash*— Potash is an important ingredient in the manufacture of many industrial products, such as chemicals, explosives, medicines, paints, soaps, matches, dyes, glass, paper, and bleaching agents, and it is indispensable in modern agricultural practices in northwestern Europe and in southeastern United States Justus von Liebig, a prominent German chemist, in 1858 discovered that potash compounds in the soil constitute essential plant foods which are not replenished by nature. Continued cropping leads to serious depletion of available potash, and this in turn causes crop yields to decline. He also discovered that productivity may be restored or increased by the application of suitable potash fertilizers. Liebig's discoveries are generally credited with marking the introduction of the scientific use of mineral fertilizers into agricultural practice Liebig must be given credit for initiating a practice which has become of world-wide importance in adding to agricultural productivity and prosperity.

While potash may be obtained from a number of different sources, four of them are of major economic importance; namely, (1) solid deposits of soluble potash minerals, (2) brines and salt lake deposits containing potash, (3) organic substances, such as sea weed and the residues from sugar factories or alcohol distilleries, and (4) dust in flue gases from cement kilns and blast furnaces The solid deposits of soluble potash minerals furnish the larger part of the present world supply,

Courtesy, Deutsches Kalisyndikat, Berlin, Germany

Fig 81 —In a German potash mine. The potash salts are banded and highly distorted. Ore loosened by explosives in borings made by electric drills

but each of the others is of commercial importance in some places. Dust from flue gases of cement and blast furnaces is becoming of increasing importance in the United States, but the major production in this country has been obtained from salt lake brines and from distillery waste

Potash in the United States.—Prior to the World War the United States was almost completely dependent upon Germany for its potash supplies When the allied blockade cut off this source, the scarcity of supplies led to record breaking

prices. As a result, potential American sources were vigorously prospected Some of the alkali lakes of the western part of the sand hill region of Nebraska had been proven to contain potash salts, and experiments in methods of extraction had been carried on for several years preceding the War. So, when supplies of foreign potash became scarce, attention was promptly directed to these lakes. Commercial production began on a small scale in 1915, and because of the fabulously high prices then prevailing, a boom in development began which lasted for three years. The total production of crude potash in the United States reached 207,686 tons in 1918, the larger part of this coming from Nebraska. Since the brines had to be evaporated by means of expensive fuel and machinery, production costs were high. Nevertheless, as long as prices for the product were sustained by the blockade of Germany, profits were tremendous and the sand hill lakes were looked upon as sources of untold wealth With the close of the war, all this came to an end. The market collapsed even more suddenly than it had developed, and this spelled the end of the potash dreams of the ranchmen in the sand hills Boom towns, scenes of tremendous building and industrial activity, and boasting of population by the thousands in 1918, became quiet villages of a few dozen people within a year Antioch and Hoffland, unheard of before the war, of more than national renown as centers of industrial activities during 1917 and 1918, have again become merely flag stops at railroad sidings.

Searles Lake, California, likewise became important as a potash producing center during the war, but because of the accessory minerals found there it was able to continue production under normal peace time conditions Its future development appears to be quite promising and of expanding significance. It is now one of the principal producers of potash in the United States. Successful commercial methods of separation of the potash from borax places the Searles Lake operators in a position to furnish the highest grade of potash salts which enter the fertilizer markets of the United States.

PRODUCTION OF CRUDE POTASH IN THE UNITED STATES

1918	207,686	short	tons
1920	166,834	"	"
1922	25,176	"	"
1924	43 719	"	"
1926	46,324	"	"
1928	104,129	"	"
1930	105,810	"	"
1932	143,120	"	"
1934	275,732	"	"
1935			
1936			
1937			

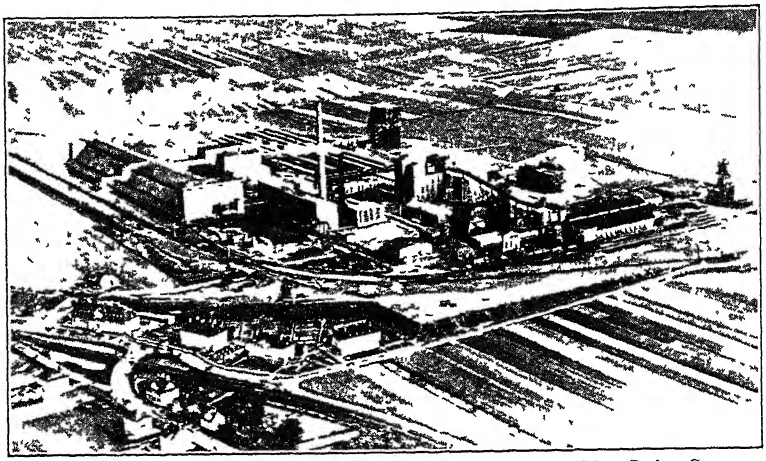
The potash output of the United States has been increasing since 1921. Successful commercial activity has been achieved at Searles Lake, California, at the extensive mining operations in the Carlsbad field of New Mexico, and where potash is incidental to other industrial activities, as from distillery refuse at Baltimore or from the dust of the cement plants and blast furnaces of Ohio and Illinois.

Large quantities of potash occur in the brines of salt lakes in various parts of the United States, but the expenses of evaporation and the separation of the potash from the associated impurities are too high for commercial exploitation at present. Extensive beds of potash salts have been found in Texas and New Mexico, and commercial production has been begun The trend of the potash industry in the United States will probably continue upward, and the competition of domestic sources will tend to keep prices of imported supplies at reasonable figures.

Potash in Europe.—Nearly 95 per cent of the world's production of commercial potash is derived from the soluble potash salt deposits of Germany and France The German deposits encircle the Harz Mountains, extending northwest under the lowlands of Hanover, and southwestward into Thuringia, they underlie an area estimated to be at least 24,000 square miles in extent. The French deposits are in the upper Rhine valley, near Mulhausen, where the potential producing area includes about 70 square miles. Estimates of the German potash reserves vary widely, but even the most conservative figures give assurance that at the present rate of consumption

they will suffice to meet the potash demand of the world for more than a thousand years. The deposits in France are estimated to be great enough to supply world demands at the present rate of consumption for over a century.

The German potash deposits were first discovered in 1851 near the east end of the Harz mountains. The potash compounds are associated with salt beds When first discovered the potash was deemed of no value and was thrown aside as



Courtesy, Deutsches Kalisyndikat, Berlin, Germany

Fig. 82.—Airplane view of German potash works. Note also the cultural landscape with its highly parcellated fields.

refuse[1] Commercial exploitation began near Stassfurt after the value of potash as a fertilizer had been proven Later exploration has shown that the potash-bearing strata extend far to the north, west, and southwest

The Alsatian deposits of France were discovered in 1904 while prospecting for oil by deep drilling methods Mines were promptly opened, and were operated under the control of the German potash syndicate until the end of the Great War. They were then taken over by the French government, which later purchased the German interests

German and French trade in potash.—German potash finds its greatest market within its own borders Owing to the ex-

tensive use of potash fertilizers in German agriculture and to the high position of the German chemical industry, domestic consumption takes 60 to 75 per cent of the total output Among foreign customers, the United States, Netherlands, United Kingdom, and the Scandinavian countries lead. Netherlands uses the most potash in proportion to area. This is due to the intensive type of Dutch agriculture and to a soil greatly in need of potash replenishment.

Production from the French mines of Alsace has been increased more than sixfold since 1913, the output of crude salts having risen from 350,000 metric tons in that year to 3,138,783 metric tons in 1930. Domestic sales lead, but large quantities are sold also in northwestern Europe and in the United States. One of the most important changes wrought by the Great War was to make France independent of Germany for her supply of potash salts.

Outlook for the world's potash industry.—Germany and France will probably continue to be the leaders in potash output for some time. Potash fertilizers are essential to agricultural production in many countries, and potash is an indispensible raw material in the chemical industries. The reserves in the countries mentioned are tremendous, and markets are secure There are, however, sufficient potash reserves elsewhere to keep the present producers of Germany and France keyed up to efficient methods and content with reasonable prices The permanency of the potash industry is assured, although it is probable that changes in its distribution will occur and that the monopoly which Germany and France now enjoy may be broken. In recent years large stores of potash salts have been discovered in Spain and Russia, and extensive exploitation is in progress Spain has already begun to export potash in large quantities, and seems likely to rival France in that respect. Russian output is increasing and may become an important factor in world trade. The United States likewise is forging ahead in potash production, and commercial development on a large scale seems assured—a situation not believed possible a decade ago.

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CHAPTER IX

Power Utilization and Industrial Development

NOTWITHSTANDING the successive waves of booms and recessions which characterize our modern economic life, this is an age of optimism. Our productivity in agriculture and in industry is such that want is unnecessary and inexcusable. We believe that the masses can and should share in the prosperity that was formerly the exclusive privilege of the few. This is in marked contrast to the economic pessimism of the past, when it was believed that the bulk of the population was predestined to inescapable poverty Although there are congested slum districts in many of the cities, wherein living conditions are deplorable, for the people as a whole standards of living have been raised to a point formerly undreamed of. People enjoy a more varied diet, wear better clothes, and have more home comforts than ever before. They are better schooled, have more amusements, and travel more. Journeys and voyages formerly limited to the wealthy few are now the expected rights of the many. Efficiency of production has reached such a high point that man can provide for his necessities and luxuries in about one half the working hours formerly required. How has this been achieved?

All through the ages and until quite recently, man was compelled to do the work of the world aided only in slight degree by mechanical power. The great change came with the utilization of the tremendous stores of energy contained in the mineral fuels. Although coal for several centuries had been used as a fuel for heating houses, its utilization as a source of power with which to turn the wheels of mills and vehicles came with the development of the steam engine, invented by James Watt

in 1763 Progress was slow at first, and the use of the coal-burning steam engine did not reach full development until about the middle of the nineteenth century This period marked the change from a slow-moving industrial pace to the modern dizzy, almost terrifying speed in industry and transportation. Since then progress among the industrial nations, and among those profiting by proximity to them, has brought with it such rapid changes in modes of living, in social standards, and even in habits of thought that adjustment from the old to the new is not easy. We are still in the process of making these changes, and the resulting problems challenge our attention.

The permanency of our modern industrial civilization will depend on the sanity with which these problems are faced and solved Means must be found whereby those who are willing to work shall have the opportunity and shall not be haunted by the fear of want The advantages of machine and power production must be extended to the masses in even greater measure than heretofore. Means must be developed whereby the leisure made available in ever larger degree shall become an asset to society instead of a liability Higher standards of living involve not only better food, clothing, and shelter; they involve better use of the hours not demanded by the routine work of daily tasks Leisure time and unexpended energy may be so utilized as to have amazing value as factors in social progress; if not so utilized, their possibilities as destructive factors may indeed appall us The maintenance and progress of social order will depend in no small degree on the intelligent solution of the problem of leisure

Since the early part of the nineteenth century the use of power resources has increased greatly in all the industrial nations of the world, but perhaps in none have the changes wrought been more profound than in the United States. This country was a young nation of vast area, of fertile land, of great wealth of mineral and forest resources, and of rapidly increasing population The population quadrupled from 1850 to 1910, a truly remarkable growth. Even so, the increase in the

generation of power usable in agriculture, manufacture, and commerce was greater still. The amount of power available per individual in the United States was more than three times as great in 1910 as in 1850, and since 1910 the ratio of power development to growth of population has been even greater than it was in the earlier period

The ability of man to produce goods with increasing efficiency is the basis of the material welfare of the industrial nations today. Less muscular energy is used, more work is done by means of mineral fuels and water power, and the direct result is increased production per man. This ability to use in ever larger measure nature's energy resources is chiefly responsible for the change which has come in the prevailing attitude toward life—namely, the change from the pessimism of poverty to the optimism of plenty This has, however, brought a new set of problems. Modern industrial progress has created such a complex economic machine that it is difficult to understand its various parts, and control is wanting. More effective guidance is among the chief objectives being sought by the great governmental experiments in Russia, Italy, Germany, and the United States

Domestication of animals provided earliest power resources.—At the dawn of human history we find man supplementing his own efforts by the use of domestic animals as a source of power resources If we go back earlier than that we must lend ourselves to the realm of conjecture and allow imagination to supply the particulars of the picture which history does not reveal. If we go back to that remote time when man was first entering into the realm of intelligence, we see him interested in selecting plants which he found most suitable for his food supply This selection gave him the impetus to take extraordinary care of those plants which he found desirable, to prevent the less desirable plants from gaining mastery over those which he favored, and to plant the seeds in favored spots With sticks or branches crudely fashioned, he laboriously cultivated his prized crops. In the very beginnings of agriculture

the only instrument he had whereby to loosen and stir the soil was the bough of a tree, obtained with difficulty, for he had no sharp-edged tools with which to cut or trim.

Inasmuch as all indications convey the idea that women were the real workers in those times, they were probably the ones who tilled the soil. It also seems likely that woman, in her attempt to provide sustenance for her offspring, was induced to supplement the food for her infant by resorting to the milk supply of some prehistoric bovine. She was led to take care of the young of such animals, to make friends with them, and thus to domesticate them, primarily for the purpose of supplemental food supply. Having available an animal which was tractable, and perhaps even docile, the next step was to use this animal as an aid in dragging branches over the loosened soil in order to prepare a smoother seed bed.

In some such manner as the foregoing we may surmise that, in the faint light which preceded the dawn of human history, man cultivated most of the common food plants and domesticated the animals which are so classified today That this process took a long time goes without saying Domestication of plants and animals was nearly all accomplished before the beginning of recorded history. Thus, when man first appears upon the stage of history, we find him accompanied not only by plants which he cultivated and prized for food, but also by animals which he was able to use as supplemental sources of power Nevertheless, the extent to which he could use them for such purposes was slight, and he depended in large measure upon his own energy to carry on the production necessary for his existence.

Human slaves as power resources.—The necessity of supplemental power served until quite recently as the basis for a widespread system of slavery. The victors in the wars of ancient and medieval times exacted heavy penalties in terms of slaves from the ranks of the vanquished. Slaves were prized as household servants, hewers of wood, drawers of water, pullers of loads, and as motive power for the merchantmen and naval vessels The production per slave was small, yet it was some-

what greater than was necessary to keep him alive and fit for work, and the surplus thus available made him valuable. Through the labors of the slaves, surplus production was made possible; and a surplus has always been necessary to supply the ruling classes with the luxuries which they demanded and to sustain a leisure class essential for intellectual progress. The latter means, of course, a leisure class only in the sense that it is a class relieved of manual labor and earning its right to live through the contributions that it makes in lines other than direct material production.

The picture of the past, therefore, bears the imprint of a great seething mass of people, slavishly toiling, but with low production per capita and a slight available surplus. The great mass of the people lived on a standard so low as to be considered impossible now, whereas the aristocracy, with all its wealth and luxuries, did not have the comforts available to the common people in the progressive nations of the present This aristocracy, however, was often instrumental in sponsoring the progress of the arts and sciences The steady advancement of mankind, from the earliest records to the present, has been due largely to the constructive accomplishments of the useful part of this class. "The Golden Age of Pericles" has been referred to by many as representative of man's highest intellectual achievements. Midst praise of this character it is well to bear in mind that then, even in prosperous and progressive Greece, the great mass of the people were but little above the status of human slaves and that only a small percentage were participants in the comforts and enlightenment which we now extol as representative of the period.

Progress leading to greater leisure and to the general spread of culture was slow until the end of the eighteenth century. Although man had made considerable advancement along industrial lines during the centuries preceding James Watt's invention, his supplementary power resources were limited to domestic animals and to wind and water utilized crudely The production per man had increased but slowly during those centuries.

The pre-industrial era of colonial days.—In order to picture clearly the tremendous progress which has been made in the last 150 years, it is helpful to give brief consideration to the industrial conditions which prevailed during the period of British colonization in the New World Manufactures were then almost entirely on a handicraft basis, and that equipment was simple indeed may be illustrated by the shoe factories of the times; these were merely groups of cobblers in a large room. Factory development progressed slowly, especially in the colonies of the middle and southern portions of the Atlantic seaboard. From the Hudson River southward agriculture held the center of the stage because land was abundant, the soil was moderately fertile, and the products were in demand.

In any new country where contacts with the outside world are difficult, men turn first to agriculture because they must eat to live and they must farm for food. In the colonial days of North America this tendency was fostered further by ready markets for the agricultural products. Grain growing became dominant in Pennsylvania, Delaware, and New York because the breadstuffs could be sold at a profit in New England and in the West Indies New Jersey, because of her abundance of grasslands interspersed with fertile valley lands, became a grazing and cattle feeding settlement Virginia and her neighbor colonies early learned the art of cultivating tobacco, a native American plant, and held virtual monopoly in that field with profits so high as to justify imports of all needed goods. Farther south the cultivation of grain crops and cotton became the principal pursuits. Labor was so scarce, wages so high, and land so cheap that a skilled mechanic could save enough of his income in six months to pay for 80 acres or more of land. Under these conditions it was little wonder that manufacturing on a factory basis did not develop on a large scale south of the Hudson and that home crafts were the dominant phases of the local industrial life ✓

In its agricultural aspects, New England was uniquely different from the colonies farther south With shorter growing season, more rigorous winters, and with soil less easily cleared,

she could not compete in general agriculture with her neighbors The bowlder-strewn land of New England had to be cleared of stone as well as of forest in order to be utilized for grain farming. This double operation was much more difficult and expensive than was the single one of forest removal in the south Since New England was thus handicapped in agricultural pursuits and since she was favored by seaboard location, she found it cheaper to import staple foodstuffs than to produce them. Local productivity was so low that the most arduous toil did not suffice to bring forth any agricultural surplus The chief land product which the New Englanders had available for exchange was white pine, especially in demand as masts for the sailing vessels of the times. The extensive seacoast, splendid fisheries, and cool climate were factors which turned an agriculture-weary people to the sea for food and for an exportable surplus.

The forest resources and protected waters of New England favored ship-building and commerce Commerce led to manufacturing, particularly of such articles as were needed for equipment or supplies for ships Iron manufactures became important, because even in the days of wooden ships much iron was needed for bolts, rods, rivets, and burrs. Massachusetts became the leading iron manufacturing colony and remained so for more than a century, prior to the Revolutionary War Rope also was needed by ships, and the impetus of this early industry is still reflected in the location of one of the largest rope factories of the United States at Plymouth, not far from the famous rock The demand for sailor's clothing led to the establishment of tailoring concerns in the seaports, and thus the foundation for an important clothing industry was firmly laid. Cooperage became a prosperous industry because of the timber readily available and the markets furnished by the demand for barrels to be used in ocean freightage

Manufactures which made use of imports of cheap raw materials constituted another phase of industry to which New England quite naturally turned. Illustrations are found in the crude sugar which was brought back from the West Indies and

refined in New England for the domestic markets. Molasses was cheaply obtained in the islands of tropical America, brought back to New England, and there distilled into rum—not a small item in the days when ships' allotments of rum for the sailors were as large as the allotment for bread Fish oils were the sources of illuminants and lubricants, and therefore the refining of such oils became important. Since cold storage and refrigeration were then unknown, the preservation of fish depended almost entirely upon the use of salt. As a result, the manufacture of salt from ocean brines became an important industry in early New England.

The diverging tendencies thus outlined characterized the industrial development of the colonial period of the New World. Factories originated and prospered in New England, while agriculture together with home crafts dominated the colonies south of the Hudson. But whether the activities were of the so-called factory type or of the home crafts, simple water power plants were the only sources of mechanical aids in doing the work The ratio of human energy to the total energy expended was high, and the output per man was low. The inevitable result was, of course, long working hours and little surplus production. All who were able to do so, toiled.

The household equipment of colonial days bore but little resemblance to that with which we are now familiar There were no furnaces, no steam heat, no electric lights, no cook stoves, and no washing machines The facilities which we know so well that we consider them commonplace were then not known There were no railroad trains, automobiles, or airplanes; no telephones, telegraphs, or radios

Industrial development in the United States—The first period: *Handicraft and introduction of water power factories, 1783-1815*—The shift of manufacture from homes to factories and from hand labor to machines did not get under way in the New World until after the second war with Great Britain. During the Revolutionary War and in the years immediately following, there was a great expansion of household

manufactures among the people of the newly-formed nation. Cut off from British supply, the colonists were compelled to turn to the job of making their own products. With labor scarce and high-priced, it was natural for them to turn to mechanical substitutes, and this proved to be a powerful impulse toward invention and improvements After the war the great drawback to development was the lack of capital for industrial enterprises, because of the youth of the nation, the heavy war expenditures, and the profits which appeared to be assured immediately in ocean commerce. Later, with trade restrictions put into effect—such as the Embargo Act of 1807 and the Non-Intercourse Acts of 1809—shipping declined and profits from that line of activity were so seriously curtailed that capital began to seek new avenues of employment. It was under these conditions that factory operation in a modern sense began to receive attention in the United States.

Before 1812 the cotton mills were small affairs, limited, for the most part, to the spinning of yarn to be sold to hand weavers The first complete cotton goods factory in America was erected at Waltham, Massachusetts, in 1814, with a loom operated by water power. Soon after this, large mills were established on the Merrimac, giving impetus to the growth of a number of cities—among them Manchester, Lowell, and Lawrence.

Cotton manufactures were among the first to be established on a big scale, because they could make use of unskilled labor. Skilled male labor was scarce and high-priced, and no industry dependent upon it could survive the competition of the cheap labor of Europe. Before the establishment of the Waltham mills, there were no means whereby women could be economically independent. Young women were soon attracted to the factory by the opportunity to earn a personal income or by the spirit of adventure Widows and unmarried women, galled by being dependent upon male relatives for charity, hailed the factory as their liberator from economic slavery New England thus presented a unique labor supply through her sailors'

wives, unmarried women, and the women of the farm, the last named struggling against the hardships which were attendant upon trying to make a living on poorly productive land

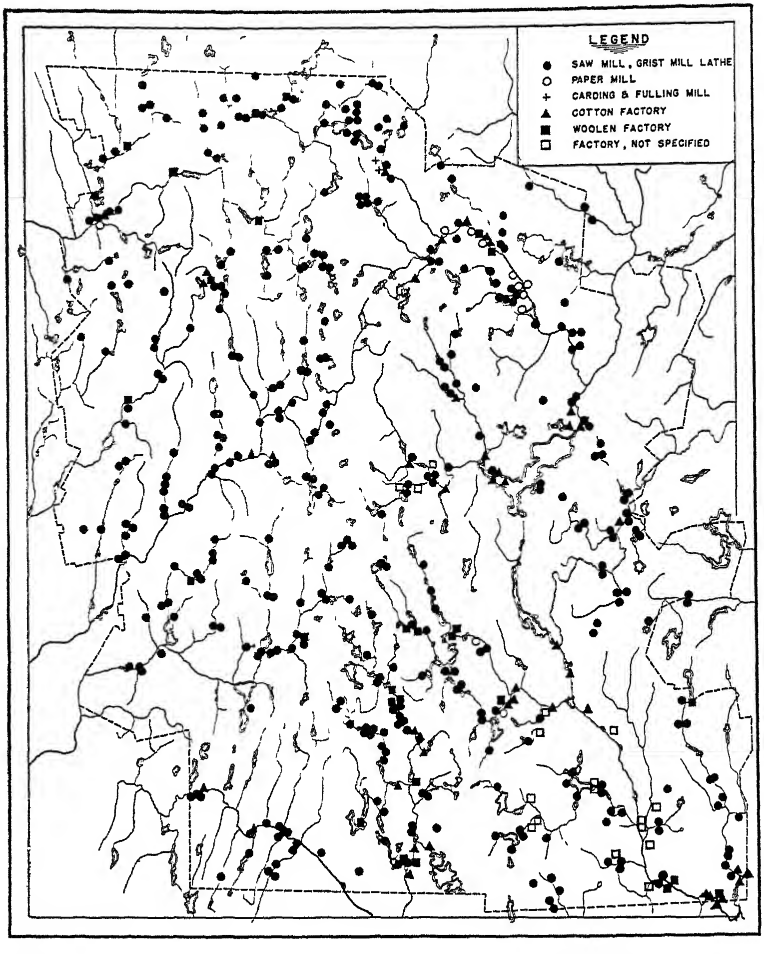


Fig 83—Small water power developments in central Massachusetts (Worcester County), 1830.

Water-power plants were installed at minimum cost along the streams of New England because of the hundreds of glacial lakes which provided natural reservoirs and assured constant stream flowage. The dams needed to supplement these reser-

voirs could be constructed at comparatively low cost Furthermore, the expansion of the factory idea came at a time when the profits of sea-borne commerce were declining, and therefore merchants were seeking other outlets for profitable investment of their capital. All these factors gave New England her early start in the cotton industry and tended to raise her to a position of supremacy which was maintained until after the beginning of the twentieth century.

The second period: *The dawn of steam as usable power, 1815-1830*—The period of 1815 to 1830 was characterized by the extensive introduction of the factory system in this country. By the end of that time the old household crafts had been relegated to a secondary role; they still existed, but their period of supremacy had passed. Never again were they to hold the center of the stage. A new force far more efficient had swung into action; against it neither man-power nor the old fashioned water-wheel could prevail The day of steam power had dawned.

Although steam power had greatly affected the industries of England, it had made little progress in the New World prior to 1815. Various factors were responsible for this retarded development, among them were (a) the abundance of land in the colonies and the high returns from grain production, (b) the lack of capital seeking investment, and (c) the substantial profits of ocean and coastwise shipping Furthermore, the new government had not impressed European capitalists as being on a sound basis, and there were many in the United States who preferred the status of an English colony to that of the newly acquired independence Credit, therefore, was almost wanting, and since steam-operated factories were comparatively costly to erect, development had to wait.

The result of the second war with Britain changed the political status of the United States from uncertainty to certainty. People both here and abroad became convinced that the new republic would live, and parties in opposition to the idea disappeared. With political stability assured, European capitalists soon realized that the United States was a profitable field for

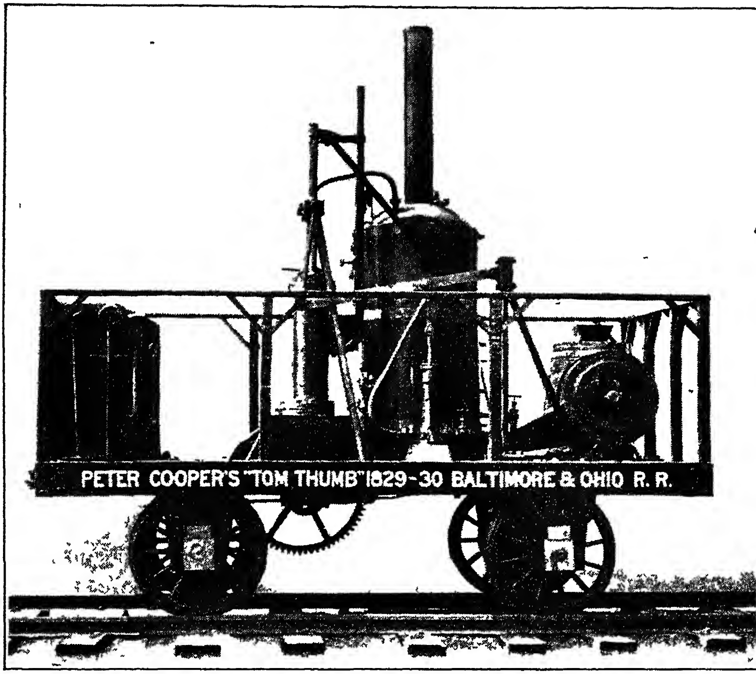
investment Both cash and credit became available and the times ripe for rapid industrial progress

Between 1815 and 1830 steam became successfully employed in stationary engines Water-power plants continued in operation, but they were supplemented or overshadowed by steam engines Handicrafts which had prospered as home crafts in the states south of the Hudson and as factory activities in New England were displaced in large measure by steam power and machine methods. The beginning of the period was marked by the dominance of handicrafts and simple factory equipment, animals and small waterpower projects furnishing the needed supplementary energy. The close of the period was marked by the eclipse of water-power by steam. Machine methods had proven their merits, and railways were winning recognition as the new and economical method of transportation These changes appear to justify the classification of the period, 1815-1830, as the transition stage from the handicrafts to the mechanical phases of the modern factory system These years brought the dawning of the steam age; its full light, however, was yet to come.

The third period: *The ascendancy of steam power, 1830-1860* —Although prior to 1830 the manufacturing industries employed but a comparatively small percentage of the population, several of the major groups, such as cotton, wool, leather, and iron, had become firmly established. The stationary steam engine had been developed into a practical power plant, and the steam locomotive had won recognition as a coming means of transportation The following three decades witnessed the greatest changes ever experienced in the operations of factories, in the building of railroads, and in the opening up of agricultural lands This period marked the change from the water wheel to the steam engine as the leading type of power plant, and in the closing years of the period coal gained supremacy over wood as an industrial fuel Steam displaced animals as the motive power for long distance land transportation. Railways were built from the Atlantic seaboard to the heart of the Mississippi Valley. Agricultural lands were thrown open for

settlement from the Alleghenies to the Missouri River, and more acres were put under the plow between 1830 and 1860 than in the three centuries preceding.

Several factors accounted for the rapid expansion of our agricultural frontier; among the more important were, (1) thousands of European peasants, poor but ambitious to possess farms of their own, found the trip to the land of promise made



Courtesy, Baltimore and Ohio Railroad.

Fig. 84.—First locomotive constructed in America. Built by Peter Cooper in 1829-1830.

possible by the improved means of transportation, (2) industrial expansion in Europe provided growing markets for American grains, and (3) the lure of the frontier and rumors of quickly attainable wealth induced many easterners to go west. These factors were made effective by the existence of the grasslands and the building of railroads in the middle part of the United States. The prairie soils were fertile and easily made

productive; to place them under cultivation involved merely plowing up the sod. No slow and expensive clearing of forest was necessary, and most of the land was bowlder-free Although large yields were obtainable with relatively little effort, without markets these would have availed but little. The railways furnished outlets to the canals and the rivers then so widely used for long distance haulage of bulky goods, thus providing the essential connections with the populous East and with ocean shipping for markets abroad The expansion of the agricultural area which characterized the period from 1830 to 1860 could not have occurred had the land been of the forest type or had railroad transportation not become available

The agricultural expansion had tremendous effects upon the economic life of the United States The farmers on the rugged eastern lands found it increasingly difficult to compete in grain production with the cheap and fertile prairies of the Mississippi Valley The developing West provided great markets for iron and steel to be used for railroad building and operation, and for the manufacture of farm machinery Construction materials of all kinds were in demand The increasing population gave rise to steadily expanding markets for manufactured goods The first great result was, naturally enough, intensified industrial progress in the East contemporaneous with the agricultural expansion in the West The railways, although slowly developing in the first half of the period, made vigorous progress later, thus adding the transportation facilities which linked the sections together Another result was the impetus given to regional division of labor in this country. As New England found grain agriculture becoming unprofitable, her people turned more largely to industrial pursuits The inhabitants of Pennsylvania awoke to the demands for coal, and so they turned in greater numbers to coal mining New York, feeling the pulsation of growing trade, turned more and more toward commerce The demand for cotton in New England and in Europe led to the development of the southland as the world's foremost cotton producing region

Throughout this period the expansion of steam railways was

the most unique movement It stamped the life of the nation, gave emphasis to an industrialized northeast, a cotton-growing southeast, and a vast grain and cattle farming area in the Ohio and upper Mississippi Valleys It was the first act in the opening drama of steam, played while the curtain had not yet been

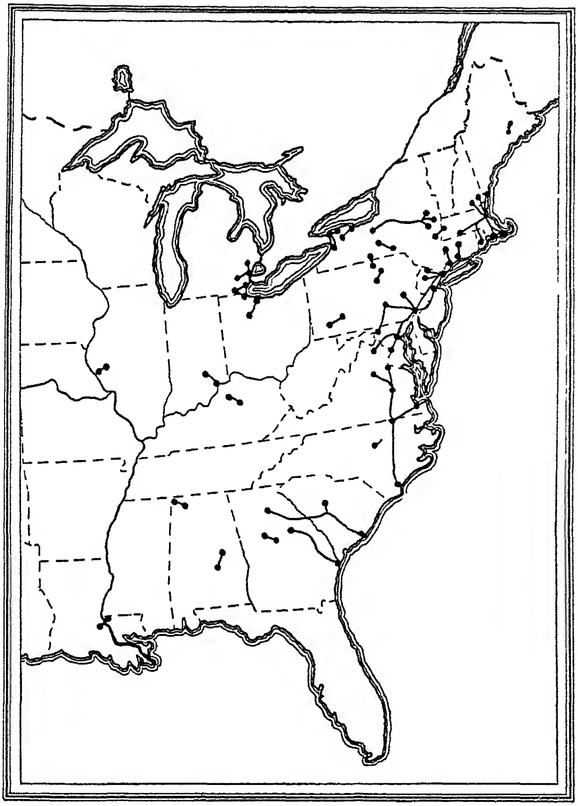


Fig. 85—Railroads in operation, 1840. (Adapted from C O Paullin and J K Wright *Atlas of the Historical Geography of the United States,* New York 1932)

lifted to reveal the potentialities of the trans-Missouri country.

The importance of capital.—The Industrial Revolution, which occurred during the decades preceding the Civil War, would have been impossible if capital had not been available with which to finance the rapidly expanding railroads and fac-

tories Fortunately, however, the early nest-egg of capital, earned through the profits of ocean shipping, gave liberal returns when first set to work in industry This went far to establish credits abroad; European investors soon became willing to furnish money at moderate rates on reasonable securities Furthermore, the output of gold which followed its discovery in California in 1849 furnished much needed capital during the latter part of this period. Money became plentiful and interest rates were relatively low With capital at hand,

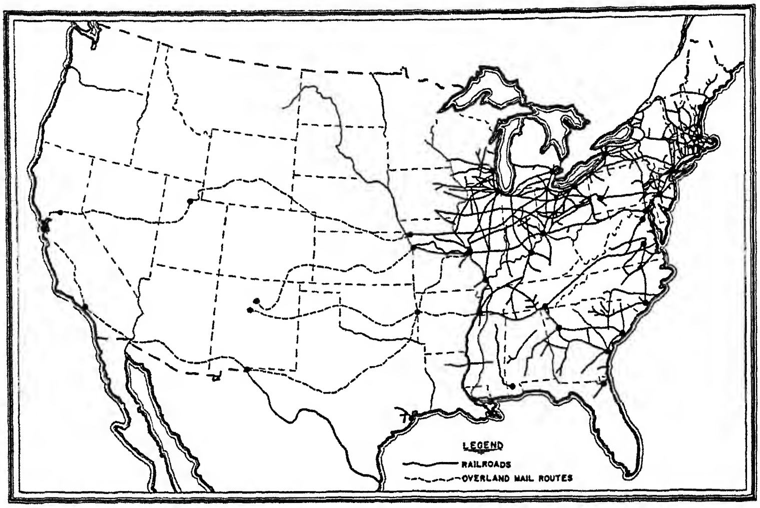


Fig. 86—**Railroads in operation in 1860.** (Adapted from C O Paullin and J K Wright *Atlas of the Historical Geography of the United States*, New York, 1932)

with raw material abundant, and with markets expanding, the manufacturing industries were rapidly growing into the full stature of maturity when they were interrupted by the Civil War. Great things were ahead, but the day of their realization was postponed by the conflict.

Geographic significance of inventions.—Nevertheless, all the lure of free land, the rewards of industrial toil, and the wonders of steam railways would have proven unavailable had not man been able to do his part in providing labor-saving machinery Whenever labor is scarce it becomes costly, and man

then becomes interested in utilizing it with the utmost efficiency Thus arises the incentive for invention, and under this spur have come a large percentage of the improvements which have characterized the industrial era. While not all the inventions which have profoundly affected our industrial civilization have been made by Americans, that they have contributed their full share is generally admitted. American and European inventions together effectively promoted the industrial advance of the past century, and the New World, with its rich rewards for inventive genius, furnished the larger part of the economic spur to progress along this line.

The net result of the three decades was that manufacturing, from the standpoint of numbers employed in it, rose from a position of relative insignificance in 1830 to such prominence that it engaged directly or indirectly a third of the American people in 1860 At the outset of the period, canal transportation was the leading method for long distance haulage of commodities; at its close the steam railroad held first place. During the first half or more of the period, wood was most commonly used as the steam-generating fuel; at its close, coal was the undisputed sovereign By 1860 coal and steam were unchallenged in their supremacy; they had vanquished their industrial predecessors, and other competitors in the realm of power had not appeared. They had caused a profound industrial revolution in the United States, while during the same period there occurred the greatest agricultural expansion that the world has ever experienced. It seems clear that coal and steam were the unrivalled keynotes of the 1830-1860 period of American industrial development.

The fourth period: *The supremacy of steam and the advent of electricity, 1860-1910.*—The period of expansion prior to the Civil War led the United States to the threshold of industrial greatness. The following half century marked the entry of the nation into the inner circle of the world's great powers. Before 1860 railroads had barely crossed the Mississippi River; in the following decades several lines were built to the Pacific coast, and the Middle West was supplied with a railroad net-

work that rivals in density that of the East. The agricultural frontier virtually disappeared when cattle raising, dry farming methods, and irrigation changed the semi-arid plains into productive lands. Domestic markets were extended to include all the territory of continental United States, an area of over 3,000,000 square miles. The size of the country, with its diversity of climatic conditions, soils, and natural resources, and likewise its diversity of needs, stimulated a variety of activities, production, and trade The absence of internal political barriers to trade encouraged each section of the country to engage in the activities for which it was best suited and to exchange its surplus products for needed goods from other sections.

Among the changes wrought in the period, 1860 to 1910, perhaps none was of more profound economic and social significance than that of the greatly increased industrialism In the early part of the period only 30 out of each 1,000 population were employed directly in manufactures, whereas in 1910, 80 persons were so employed In 1860 there were slightly more than four persons working on farms to each one engaged in a factory; in 1910, the ratio had fallen to 1 6 persons on the farm to one in the factory In 1860 the United States was of little consequence in manufactures among the nations; in 1910 it had become one of the leaders The growth had been so gradual that few people sensed its importance. Manufactures had expanded chiefly in response to the growing home demands, and the entry of manufactured goods into world markets on a large scale had barely begun.

The most radical and far-reaching industrial event of the period was the introduction of electricity into the commercial field. From a practical point of view this was inaugurated by the introduction of the incandescent electric light, Edison's epoch-making invention of October 21, 1879. Development was so rapid that its use had become nearly universal by 1910. Through its application, water power was developed on a scale little dreamed of in the days of the "mill and the brook " Electricity, although not yet at its zenith as industrial power, had become one of the most potent forces of the times.

209,000,000 barrels in 1910. Kerosene lamps displaced candles and tallow dips in nearly all countries of the world, a change so important that some students have considered the kerosene lamp the most effective civilizing agent of the times Petroleum also provided inexpensive lubricants of superior quality when the machine age was calling for them in large quantities The high-speed machines which marked the later years of the period were made possible by the high quality lubricants derived through the refining of petroleum.

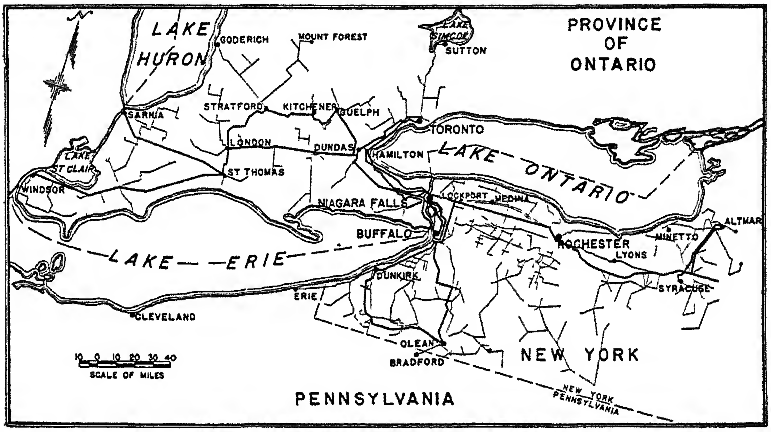
Petroleum and electricity were both essential in the development of internal combustion engines; without the light weight and effective power of such engines, automobiles and trucks could not have become the common carriers of man and freight that they are today. After years of discouraging pioneer efforts, 1910 found the automobile ready to take its place as a commercial success and to serve as the basis of one of the greatest of the world's industries.

Nevertheless, tremendous as the growth of power had been in the half century preceding 1910, it was not *distributable.* Steam had to be used where generated. The boiler had to be operated near the engine, and from the engine power could be transmitted by means of a leather belt to a pully shaft, but no farther. Electricity was at first but slightly more elastic than was steam power. It could be delivered cheaply only to a compact and relatively congested population Where population was sparse or communities remote, electricity usually was too costly for industrial purposes. As a consequence, both steam power and electricity were conducive to concentration of industry where raw materials could be made available near great markets. All these tendencies pointed to ever increasing congestion of population and the concentration of industry and wealth in urban centers

The fifth period: *The age of distributable power, 1910 to the present.*—Until about 1910 factory development tended toward the formation of small, excessively compact industrial districts around nuclei of available power or great markets. In the years immediately following, long-distance transmission of

electricity became practicable, a change of such potential consequence that we look upon it as inaugurating a new stage in industrial progress. We believe that this movement must eventually lead toward decentralization of industrial enterprises; power available where needed will tend to discourage undue congestion of population and serve to increase prosperity and well-being in general.

Since 1910 there has been constructed in the United States a network of more than 100,000 miles of high-voltage power lines. Through these facilities electrical energy is distributed over a large part of the country, and an adequate power supply has



Courtesy, N R Gibson, Buffalo, Niagara and Eastern Power Corporation

Fig 88.—Map showing distribution of electricity from Niagara Falls.

thus become an asset not only of the big cities, but also of towns and villages nearly everywhere. Over half of this mileage has been built in the past ten years.

Other great decentralizing movements characteristic of the period since 1910, and which are still in progress, are the construction of all-weather highways, the universal use of the automobile, the vastly improved railroad service, and the advent of airplanes as commercial carriers of freight and passengers. We cannot yet measure the effects which will inevitably accompany these changes, but that their ultimate results will tend toward decentralization seems highly probable

The automobile is largely responsible for the popularity of suburban residences, thus adding to the value of outlying lands while having the opposite effect on lands in the former peripheral areas of the cities The decentralizing tendencies in industry are already in evidence in the development of local manufacturing villages and towns, associated with, but located miles away from, great cities such as Los Angeles, Detroit, Cleveland, Chicago, and New York. The virtual abandonment of some of the downtown sections of London and New York as residential districts illustrates the effects of rapid transit on the distribution of city populations.

The movements, now in progress, toward developing small, widely scattered industrial centers, where workers may have homes on individual plots of tillable land, are further illustrations of the decentralizing tendencies induced by distributable power Although the movement toward decentralization is in its early stages and much further development must occur before its influence becomes highly effective, we believe that continued progress along this line is assured With such progress the slum conditions associated with factory cities will gradually disappear and living standards will rise in substantial degree Distributable power apparently is destined to contribute much toward overcoming the evils of congestion in industrial districts, and it seems likely to become recognized as the keynote of the present period.

Fundamental resources essential to industrial progress.— When energy became mobile the way was opened by which much human drudgery could be relieved or largely avoided. Man must of course continue to labor, but now his province is essentially in the direction of machine activity instead of being the primary source of power. The emancipation of man from the toil and inefficiency of earlier ages and his elevation to the productiveness and comforts of the present are the fruits of our industrial civilization Fundamental to this achievement is the utilization of the great sources of energy, namely, coal, petroleum, natural gas, and water power. The energy from these sources, converted into power and applied to raw materials

through machinery, does the work of the times. To all it *can* furnish food, raiment, shelter, the comforts of travel, and luxuries such as no people, not even the kings, were privileged to enjoy in the past.

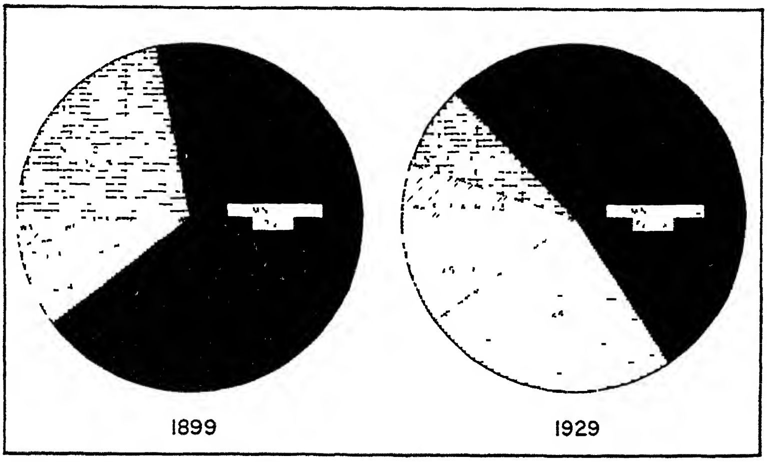


Fig 89.—Graphs showing sources of energy in the United States in 1899 and in 1929 (wind, animal power, and firewood omitted). (Source of data *Mineral Resources of the United States*, Bureau of Mines, Washington, D C)

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CHAPTER X

Coal as a Fuel and Power Resource

ALTHOUGH no longer monopolizing the stage, coal is still the foremost fuel and power resource upon which modern industry depends. Its relation to industrial development is so intimate that any close distinction between cause and effect is impossible That the enormous expansion of coal mining during the past century has been due to the introduction of labor saving machinery and mechanical devices for power utilization is undeniable, but it is also true that such machinery could not be utilized, in fact it could not be made, if coal were not available to furnish the heat and driving energy.

Generally speaking, the great industrial nations of the world are the great coal using nations. The astounding material progress made by England, France, Germany, and the United States has depended to a greater degree upon the energy available in coal than upon any other source. Huge engines convert this energy into power for factory operations, steamship navigation, and railroad transportation Coal is the principal fuel used in smelters, furnaces, and domestic heating plants. In addition to these major uses it is the source of numerous by-products, some of which are so important that they are known as key materials without which many industrial processes would not be possible.

The economic significance of coal in the United States is evinced by the fact that in a normal year the output is nearly 600,000,000 tons and coal mining gives employment to about 700,000 men Coal has long been the greatest single item of railroad freight The value of the annual output places it among the leading three or four commodities produced in this country The coal mining industry, because of its magnitude

and its intimate relation to other economic pursuits, has become recognized as one of the leading barometers of the nation's business.

Historical sketch.—It is claimed by some historians that coal was used by the Chinese many centuries before the dawn of the Christian era. The accessibility of coal where there was pressing need for fuel may have lead to some simple mining in ancient times, but until recently, little development had taken place. Even now the coal industry of China is small in proportion to the size, resources, and needs of the country.

In Europe the earliest reference to coal appears to have been made by Aristotle in his textbook on meteorology, wherein he refers to a "coal-like substance." That coal was used by Grecian blacksmiths in heating iron so that it could be hammered and shaped into desired forms is proven by statements of Theophrastus and Pliny. Thus it seems that even in early times some uses were made of the meager coal resources of Greece and Italy. But because of the small reserves and poor quality of the coal, the difficult mining conditions, and the relatively mild climate, coal mining never became important in the Mediterranean countries

Since the conditions of the environment in northwestern Europe differ sharply from those in Greece, Italy, and Spain, it was quite natural that coal mining should become important there at a relatively early date In many districts the rapid depletion of the forests, which resulted from the expansion of the agricultural area and the increase in population, led to a scarcity of wood for fuel With the cold, dreary winters of northwestern Europe, lack of cheap fuel caused much discomfort The discovery that the shiny black rock outcropping along some of the valley sides had the peculiar property of burning with intense heat was an important fact in economic history, a fact which was destined to have far reaching results As long as coal was used only for heating, progress of the coal mining industry was slow Even in England, then the most highly developed coal mining country in the world, the total annual production in the beginning of the eighteenth century was less

than 3,000,000 tons, and the output per worker was exceedingly low.

After the introduction of the steam engine the demand for coal grew slowly for a number of years, because wood was still available at low prices in many districts The fireboxes for the early boilers were designed for wood, and hence they did not function well for coal. But as the steam engine was improved and its economic efficiency became recognized, its use expanded with increasing rapidity; scarcity of wood for fuel became more strongly felt and the price mounted rapidly In response to this economic pressure, fire boxes adapted for coal were designed, and they soon became successful Because of the scarcity of timber in Europe, this development occurred there sooner than in America, but even so it did not reach great importance until early in the nineteenth century In the United States coal did not really come into its own as a power fuel until after 1850 (See Fig 90)

Development of the coal mining industry of the United States.—The earliest mining of coal in the American colonies was carried on by individuals who found outcrops along valley sides, and took out small quantities for their own use Whether we should term this practice mining may be doubtful. There seems to be definite evidence that some mining was carried on in a small coal basin near Richmond, Virginia, about 1787 Coal mining as an industry, however, can hardly be said to have existed in this country until after 1820 In 1821, the earliest year for which a statistical record is available, the total output was only 1,322 tons From then until 1910 production increased at a rapidly accelerating rate From 1820 to 1850 the ratio of progress during each decade was tremendous, but as measured by present standards it involved only moderate tonnage increases During the sixty years from 1850 to 1910 each decade virtually doubled the output of the preceding one and tonnage increase was great Since 1910, although marked yearly fluctuations have occurred, the general level of coal output has remained practically unchanged, a condition attributable to the influence of the increased competition of petroleum, natural

gas, and hydro-electric power, and to marked improvements in the efficiency of steam engines

The important constituents of coal.—The principal constituents of coal, those upon which its heat value depends, are fixed carbon, hydrocarbons, moisture, and ash Coals with high percentages of the first two have relatively great heat value, while those with high moisture and ash content have low rank. Coals vary greatly in these respects

Carbon is one of the principal products of the partial oxida-

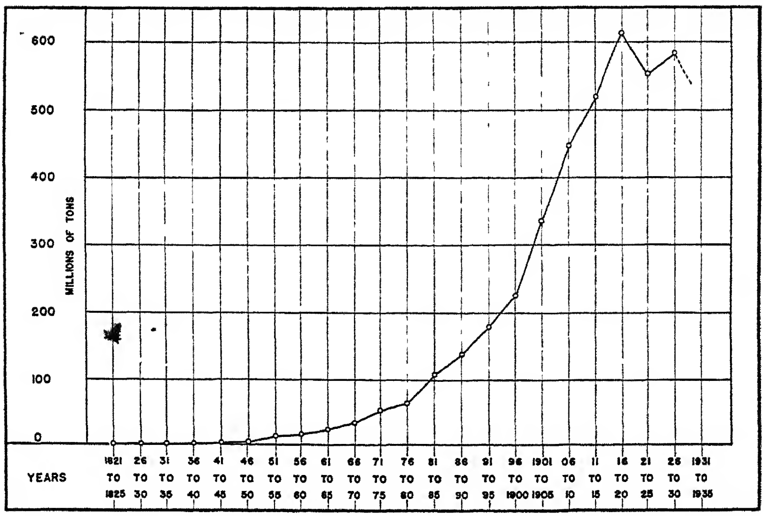


FIG. 90 —Production of bituminous coal and anthracite in the United States from 1821 on, according to five year averages (Source of data *Mineral Resources of the United States*, Bureau of Mines, Washington, D C)

tion of woody matter Since coal is of plant origin, it is only natural that carbon would be one of its chief constituents It is this element which imparts the black color and burns with little flame, high heat, and practically no smoke Inasmuch as coals which are rich in carbon are usually low in the impurities which reduce heat value, the percentage of fixed carbon is accepted in the trade as indicative of the quality of the coal.

The hydrocarbons consist of hydrogen and carbon chemically united in varying proportions. These compounds, having 1 3 to

4 times as much heat value as has fixed carbon, increase the efficiency of coal as a fuel. Coals that are rich in hydrocarbons but low in moisture and ash are easily fired and are the most desirable for steam generating purposes

Moisture in coal is an undesirable constituent. There are two principal kinds of moisture—namely, extraneous and inherent. The former is water in contact with coal particles, filling or partly filling the little spaces between them Extraneous water will evaporate from coal stored under dry conditions Inherent moisture, on the other hand, is chemically combined and does not evaporate to any great extent upon exposure to the air.

Moisture has weight, which in this case is reckoned as coal but has no heat value. Furthermore, by absorbing heat when the coal burns, water reduces the efficiency of the fuel in somewhat greater ratio than is indicated by its percentage Evaporation of the moisture not only causes loss of weight in shipment or storage, but also causes checking and crumbling whereby much of the coal is reduced to small particles—known to the trade as *slack*—thus seriously impairing the market value Some coals have so much moisture in them that when they are burned in a strong draft the sudden change of the water to steam occurs with such explosive violence that flaming coal particles are blown out through the smoke stacks

The ash content of coal is of course incombustible and therefore of no heat value. In some coals, fusible ash gives rise to masses of clinkers which interfere with the air draft and are difficult to remove from the grates of fireboxes. Such coals are not so economically fired under boilers as are those known as *clinkerfree* In all cases, ash is a diluting constituent. One per cent of ash is equivalent to 20 pounds per ton, and of course that is waste in storage, handling, and transportation. Some coals have as high as 12 to 15 per cent ash, and in such cases the economic significance of the ash is evident. Steamship operators desire bunker coals with low ash content because of the business necessity to use all cargo space and tonnage to the best advantage. Ash is not economic cargo

Leading uses of coal.—The uses of the coal mined in any given district are determined by a few principal factors; namely, heat value, storage quality, cleanliness, its coking or free burning properties, and its ability to compete with other coals or other fuels. In the United States the use of coal for power purposes, including transportation, ranks highest and accounts for about 66 per cent of the total annual output All coals

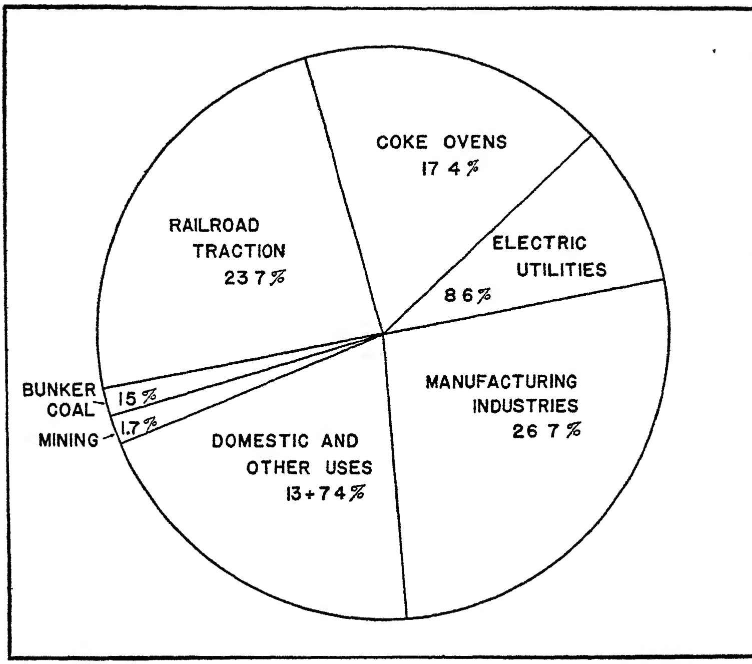


Fig 91 —Consumption of bituminous coal in the United States by uses. (Source of data *Mineral Resources of the United States*, Bureau of Mines, Washington, D. C.)

used for this purpose are known in the trade as *steam coals*. About 22 per cent of the production is used in the manufacture of coke and by-products

Coking coals are those which may be fused when burned with an amount of air insufficient for complete combustion or when heated in retorts. Modern coke manufacture is carried on by the retort method, whereby the by-products are saved, among the most important of which are gases and chemicals.

Coke is essential in the smelting of iron ore, and therefore the retorts are commonly located where coal of coking quality is obtainable and where the markets provided by blast furnace centers are convenient. Pennsylvania is by far the leading state in coke manufacture; it is followed by West Virginia, Alabama, Indiana, and Illinois

Kinds of coal.—Classification of coal into a systematic series is credited to Parker and Campbell, who for a number of years were in charge of coal investigations for the United States Geological Survey This classification has been widely accept-

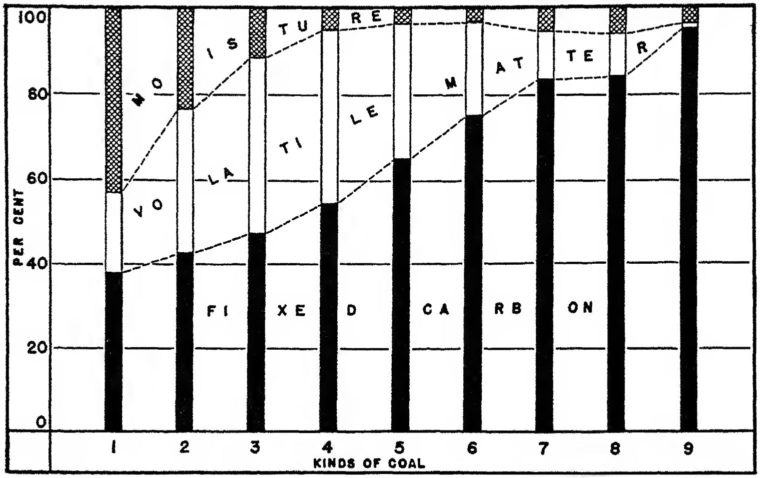


Fig. 92.—Contents of different kinds of coal. (After M R Campbell, *Professional Paper* 100, United States Geological Survey, Washington, D C)

1 Lignite
2 Subbituminous
3 Bituminous, low rank
4 Bituminous, medium rank
5 Bituminous, high rank
6 Semi-bituminous, low rank
7 Semi-bituminous, high rank
8 Semi-anthracite
9 Anthracite

ed as scientifically sound and has proven practical for industrial purposes It begins with peat and ends with graphitic coal, the successive members in the series having been selected chiefly upon the bases of coherence and fixed carbon content.

Peat.—Peat occurs in bogs, especially in areas of cool temperate climates where slow accumulation of partly altered

vegetative fibers has given rise to deposits of varying extent and thickness. Its vegetable origin is clearly evident in the fibrous structure of the mass The largest known deposits occur within the glaciated areas of the Northern Hemisphere, notably in Ireland, Scandinavia, Finland, Russia, north-central United States, and Canada Commercial production of peat is greatest in Ireland because of the extensive deposits which can easily be worked and because of the markets furnished by the large population in need of a cheap fuel. After drying, peat burns readily, gives a hot flame, and is relatively low in

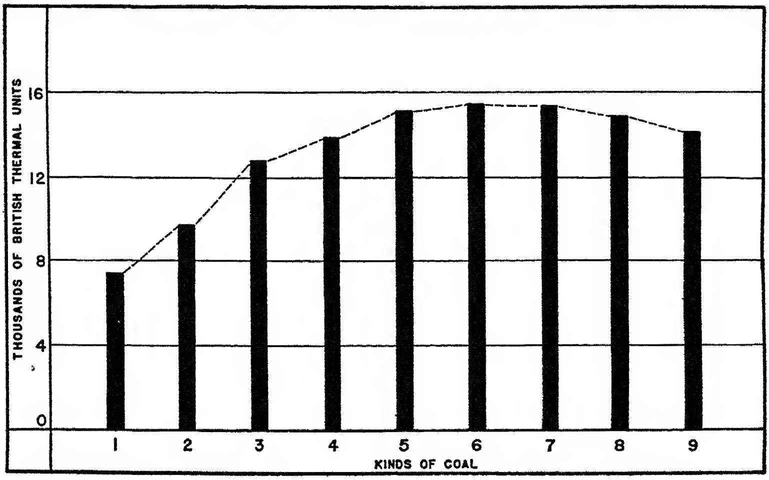


Fig 93.—Heating value of different kinds of coal. (After M R Campbell Source as for Figure 92, same kinds of coal)

ash content. Its bulk, however, is a handicap because it necessitates much storage space and involves high charges for shipment. Various attempts have been made to convert peat into smaller bulk through briquetting, but since this process adds materially to the cost, it is difficult for peat briquettes to compete with those made of fine coal

Lignite.—True lignite is brown in color or has a distinct brownish cast. The higher grades vary from dark brown to almost black It is characterized by a high moisture content ranging from 20 to 40 per cent of the weight when freshly

mined. The structure is fibrous to woody The fixed carbon content ranges from 30 to 55 per cent, the lower number being more common than the higher Among the principal handicaps to the use of lignite are its tendencies to crumble badly in shipment and in storage, thus giving rise to a large amount of fine coal which is erroneously called slack This fine coal has about as much heat value as the fresh lump lignite, but since it burns less readily under ordinary furnace conditions it must be marketed at a sacrifice.

In the United States extensive lignite deposits occur in North Dakota, northwestern South Dakota, and eastern Montana. Lignite is also known to be present in large areas of the Gulf Coastal Plain from Texas to Alabama In Europe the most extensive beds are in the north German lowland, where they are mined on a large scale for domestic and industrial purposes.

Subbituminous coal—Subbituminous coal is often called black lignite in trade circles Its color is black, varying from dull to brilliantly lustrous, the structure is compact, and the fixed carbon content ranges from 35 to 60 per cent. It burns freely, is clinker free, and has much higher heat value than lignite. Since it is non-coking, in connection with ore smelters it can be used only as a steam coal The free moisture content is relatively high, a serious trade handicap because evaporation causes the coal to crumble into slack, thus causing losses in transportation and storage. Furthermore, upon being burned in locomotives or other furnaces with strong drafts, subbituminous coal is likely to cause eruptions of sparks which become a fire menace to the vicinity. Despite these drawbacks, coals of this class serve important local markets in the western plains, where higher grade coals are remote and therefore costly because of transportation charges.

The best known subbituminous coal region in the United States is in the Great Plains, in the so-called Sheridan district of northern Wyoming and the adjacent part of Montana. High quality coals of this kind occur also in the Denver Basin and throughout extensive areas within the Rocky Mountain

region Because of the losses in weight and marketability if the coal is kept long in storage, the mining industry is largely seasonal. During autumn and winter, relatively heavy demands lead to great activity; spring and summer are slack seasons when operations are almost at a standstill except in the mines which serve the railroads and the local industrial plants.

The outlook for the near future does not point to any marked improvement in subbituminous fields In the more distant future, when petroleum will not be so plentiful as it is now, the utilization of this kind of coal is likely to increase. Its high hydrocarbon content makes it available for the manufacture of artificial gas and liquid fuel. The liquefaction of coal, which at present is chemically but not economically possible, may develop into an industry of major significance. The enormous quantities of subbituminous coal known to exist in the Great Plains and Rocky Mountains, the comparatively low cost of mining in many places if all-year operation can be maintained, and the low cost of transportation of liquid fuels are factors which some day may lead to extensive exploitation But that day still seems quite distant.

Bituminous coal.—Bituminous coals are usually black, varying from dead black to highly lustrous. The moisture content, although subject to considerable variation, is relatively low The fixed carbon content ranges from 48 to 73 per cent. Since they break down more slowly upon exposure than do lower grade coals, they may be kept in storage for months practically unchanged. Upon disintegration through exposure they may break into small particles, but the heat value is not seriously impaired.

Bituminous coal constitutes about 52 per cent of the estimated total world's supply. It is the kind used chiefly for industrial purposes. In the United States the well-known producing districts are in the Appalachian Plateau, extending from western Pennsylvania and eastern Ohio to Alabama, in the interior plains of Michigan, Indiana, and Illinois, and southwestward to Missouri, Kansas, and Oklahoma. Coals

of this type furnish by far the larger part of the fuels used by the factories and the railroads of the United States.

A special kind of bituminous coal, characterized by its denseness and its dull black color, is known as *cannel coal* The absence of woody material gives it smoother grain than that of other coals. Owing to its richness in inflammable constituents, the best grades will ignite readily when a lighted match is held in contact with a small splinter of the coal It burns with a long yellow flame and it is especially well adapted for gas making, for use in fireplaces, and for quick kindling purposes in

Courtesy, Southwestern Interstate Coal Operators' Association, Pittsburg, Kansas

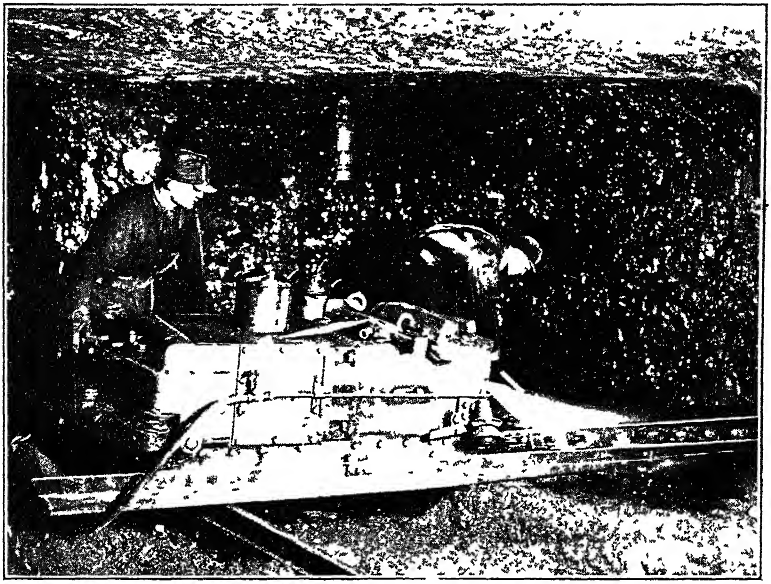
Fig. 94.—Open-pit bituminous coal mine, near Pittsburg, Kansas. Note coal being loaded into freight cars.

furnace operation The best known cannel coal districts are found in Kentucky and Tennessee.

Bituminous coals are broadly classified as coking or noncoking Inasmuch as coke is the essential fuel in blast furnaces, high-grade coking coals are in great demand in the iron and steel centers of the world Extensive beds of coal of this quality are being mined in western Pennsylvania and in West Virginia; these have contributed greatly to the prominence of the industrial centers which have developed at Pittsburgh, Youngstown, and Cleveland

Semibituminous coal—Although the term semibituminous seems to imply that this grade of coal is half the rank of bitu-

minous, it is used for a kind of coal that is of higher rank Super-bituminous would seem to be a more appropriate designation. The color is rich black, usually of high luster. Cohesion is often weak; for this reason semibituminous coal tends to crumble into small bits when handled The fixed carbon content is high, 73 to 83 per cent. Because of this high percentage of fixed carbon, the coal may be burned without much smoke, and consequently most semibituminous coals are known



Courtesy, United States Bureau of Mines, Washington, D C

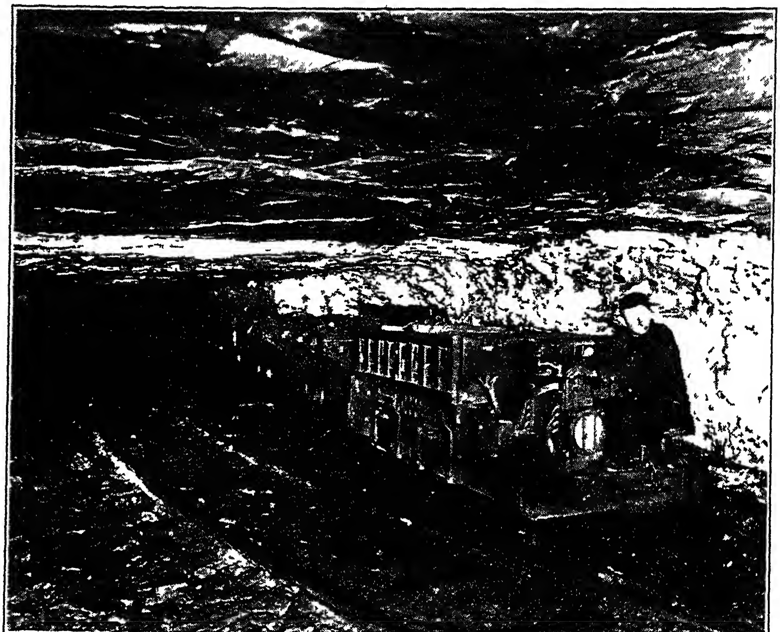
Fig 95.—In an underground coal mine. Modern method of undercutting coal by machine

to the trade as *smokeless coal.* Moisture content is low and heat value is high; these qualities make it splendidly adapted for steam purposes and for use in manufacturing processes wherein high temperature operations are necessary Because of the low percentage of ash which usually characterizes it, it is in great demand for bunker coal.

The principal handicap connected with semibituminous coal is its friability This property causes it to crumble in mining and in transportation, thus giving rise to a large percentage

of fine coal which is regarded unfavorably by many users Through the perfection of mechanical stokers and grates adapted to fine coal, this handicap has been overcome, and for some purposes fineness is an asset rather than a disadvantage.

Semibituminous coals are found mostly in connection with eastern fields, the best known districts being Pocahontas, West Virginia, and in the eastern parts of the Appalachian Plateau



Courtesy, United States Bureau of Mines, Washington, D C

Fig. 96.—In an underground coal mine. Modern method of transporting coal by storage battery locomotive.

region of Maryland and Pennsylvania. Some of the high grade, metamorphosed coals mined on the slopes of the Arkansas River valley and along the flanks of the Ouachita Mountains of Arkansas and Oklahoma may also be classified as semibituminous.

Semianthracite coal.—Semianthracite coal differs from semibituminous chiefly in having a higher ratio of fixed carbon, nearly 83 to 93 per cent, and a correspondingly lower percent-

age of volatile matter. It differs from true anthracite in its friability rather than in its heat value. The cohesion, or so-called hardness, is only moderate and thus semianthracite coals are likely to break down from lumps into fine coal during the handling necessary in mining and transportation.

The best known mining districts are near Bernice, Pennsylvania, and along the flanks of the Ouachita Mountains of Arkansas and Oklahoma. Semianthracite coal is a clean burning fuel, giving but little smoke when properly used, and the heat value is as high as that of anthracite. The qualities of being almost smokeless, free from soot, and burning slowly and persistently, make it a desirable fuel in domestic heating. It is, therefore, the most popular furnace fuel throughout a relatively large territory tributary to the Ozark Highlands, its largest markets being the cities north and northwest of St. Louis.

Anthracite coal.—Anthracite coal is hard, dense, and relatively free of iron compounds and moisture. The amount of fixed carbon is about the same as that in semianthracite, ranging from 80 to as high as 95 per cent of the total weight Anthracite is characterized by its jet black lustrous color and excellent coherence The texture is fine, giving to the broken surface a smoothness which is almost a polish. It differs from semianthracite particularly in its hardness, a quality much desired by the trade because it permits preparation of sizes adapted to particular needs Inasmuch as there is virtually no loss in storage and no danger of spontaneous combustion, it is well adapted for summer purchase by consumers. This is an important factor in the steady monthly output of anthracite in contrast with the sharply seasonal fluctuations of the bituminous mines.

Anthracite coal burns with a short blue flame with practically no smoke. Although it kindles with difficulty, when once the fire is started it is remarkably persistent and can be regulated to give much or little heat as the conditions may require. Cleanliness, steadiness in burning, and the lack of deterioration in storage are the properties which make an-

thracite the most popular of any of the coal series for the heating of homes and business blocks.

In the United States there is only one prominent anthracite district—namely, the so-called Scranton and Wilkes-Barre area of northeastern Pennsylvania The availability of anthracite from such nearby sources for heating the homes, office buildings, and factories in the great cities of northeastern United

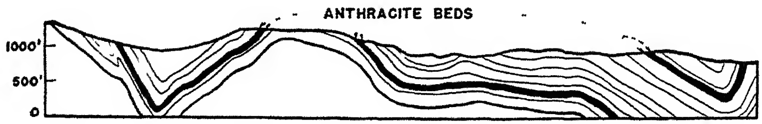


Fig. 97 —Section through Southern Anthracite Basin, north northwest of Pottsville, Pennsylvania. (Source *Twenty-second Annual Report of the United States Geological Survey,* Part III, Washington, D C, 1901)

States has been of tremendous economic importance Furthermore, it accounts for the absence of palls of smoke such as often occur where large cities have to depend on bituminous coals.

Graphitic coal.—Where metamorphism has gone further than to produce true anthracite, the carbon content may have been changed into graphitic form Such coals burn with so much difficulty that they have little importance as fuels A small district at the head of Narragansett Bay, Rhode Island, is known to have coal of this kind, which has no industrial significance.

Distribution of coal in the United States: *The Eastern Province.*—The coal fields of the United States are usually grouped under six major provinces; namely, the Eastern, Interior, Gulf Coast, Northern Great Plains, Rocky Mountain, and Pacific Coast.

In output the Eastern Province has always held commanding leadership. Included in this province is the anthracite region of northeastern Pennsylvania While anthracite accounts for but 12 to 15 per cent of the total annual coal output of the United States, its use for heating purposes in the densely populated northeastern sections of the country gives this

region a much more important place in our economic scheme than its share in the total production might indicate The Eastern Province owes its economic supremacy, however, to the extensiveness of the Appalachian bituminous region and to the high quality of coal found therein. From an industrial point of view, this has been aptly termed the greatest coal region in the world. It extends from northwestern Pennsylvania and eastern Ohio, through West Virginia into northern Alabama The coal occurs under favorable mining conditions, has high heat value, keeps well in storage, and is of unexcelled

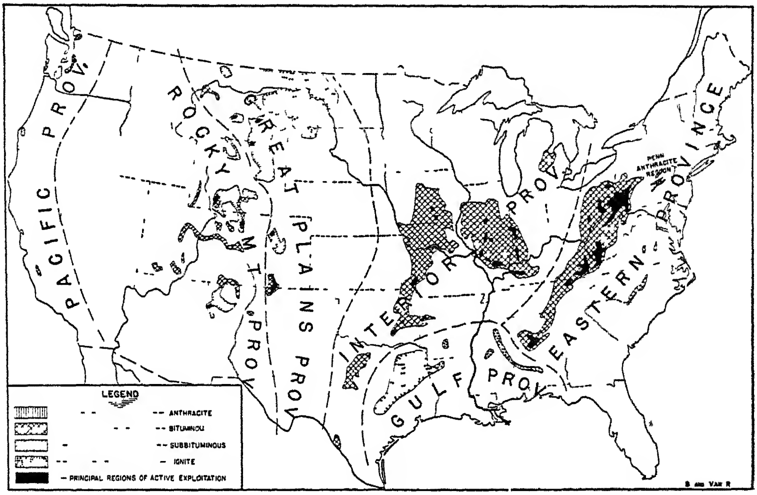


Fig 98.—Coal provinces of the United States and principal regions of coal mining.

coking quality. The mining districts of this region furnish the industrial fuel for railroads and factories throughout eastern United States, and the coal has great importance in gas making, in generating of electric power, and in domestic heating

The high position of the Eastern Province in the American coal industry is revealed by the fact that it contains four of the five states which lead in coal output, namely, Pennsylvania, West Virginia, Kentucky, and Ohio. The industrial centers from Cleveland, Cincinnati, and Nashville to the Atlantic coast depend largely upon the coal output of this pro-

vince. The low cost, high quality coal has been an essential factor in the industrial development of that part of the United States.

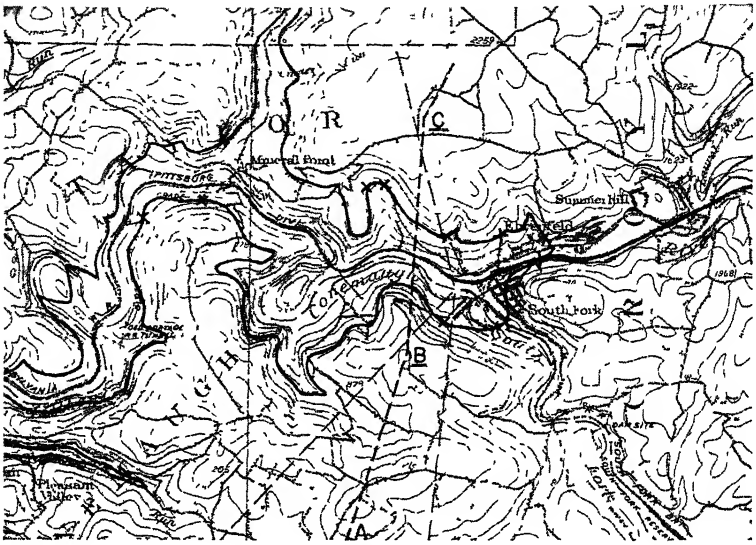


Fig. 99.—Topographic map of part of the bituminous coal field of the Appalachian Plateau, Cambria County, Pennsylvania. Outcrops of the principal coal bed shown by heavy black line. Mines indicated by crosses

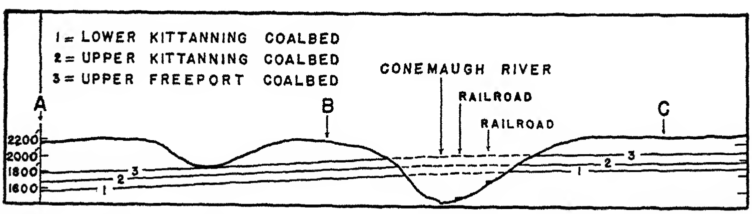


Fig. 100.—Generalized profile along lines A-B-C of figure 99

The Interior Province.—The Interior Province includes four regions namely, the northern interior in Michigan; the eastern interior of Indiana and Illinois; the western interior, embracing the coal fields of Iowa, Missouri, Kansas, Oklahoma, and Arkansas; and the southwestern interior in Texas. Only the first three, however, have attained commercial importance.

In the Interior Province, the coals in the two regions east of the Mississippi River owe their economic importance chiefly to the demands of industry and transportation. Furthermore, the comparative density of population and the severity of the weather during the winter months give rise to important market demands for coal for heating homes, office buildings, and industrial plants. The coal of Michigan, although not of coking quality, is an important asset for Detroit and other industrial centers in the southern part of the state. The Indiana and Illinois fields have huge markets in the great industrial cities within and adjacent to those states. Illinois—particularly fortunate in the extensiveness of its coal fields, in the low cost of mining operations, in the high quality of coal, and in the availability of large markets, especially those of the Chicago and St Louis industrial areas—has become one of the three states leading in annual output of coal

A factor of great importance to the coal industry of the interior states east of the Mississippi is the Great Lakes waterway, which provides a cheap transportation route to the northern markets of the United States and adjacent parts of Canada There the winters are long and severe, and local coal supplies are wanting. Because of the heavy movement of iron ore southward, competition for north-bound cargo is so keen that the coals of the Appalachian field—from West Virginia, Pennsylvania, and even from Kentucky—enter into serious competition with the coals of the Interior fields for the northern markets.

The coal of the western interior region is characterized by its high heat value and by its range in quality from anthracite to bituminous Along the flanks of the Ouachita Mountains of Arkansas and Oklahoma, folding has caused metamorphism of the coal into the anthracite group. Since it is friable rather than coherent and hard, it is classified as semianthracite, although its fixed carbon content is nearly the same as that of the Pennsylvania anthracite. Because of the high heat value and freedom from smoke when burning, it has attained importance as a furnace fuel in the extensive trade territory to

the north of Oklahoma and Arkansas. Elsewhere in the western interior region only bituminous coals are found. The demands for domestic use are impaired by the fact that most of the bituminous coal burns with considerable soot and smoke, and therefore it is called "dirty" by the trade However, its high heat value and low cost at the mines make it a prized steam coal for industrial and railway uses Exploitation is limited by the comparative sparseness of industrial plants within the trade territory and by competition with petroleum and natural gas.

The southwest region is in central Texas The coal is bituminous, not of very high grade, and has no economic value at present because of lack of markets.

The Gulf Coast Province.—The Gulf Coast Province extends from Texas to Alabama. Only lignite coal of poor quality has been found there; this, together with difficult mining conditions and competition with superior fuels, has prevented exploitation to date There is no prospect of any improvement in the near future.

The western coal provinces.—The Northern Great Plains and the Rocky Mountain Provinces contain enormous reserves of unmined coal varying from lignite to high quality bituminous Exploitation has been chiefly for use by railways, ore smelters, and for domestic purposes. Local mines have long been of great importance to the communities which they serve and to the railroads which traverse the regions. The mining and smelting industries of the Rocky Mountain districts have been enabled to operate at relatively low cost because of the coal obtainable from nearby workings The total amount of coal produced has been small, however because of the sparseness of population in the vast territory included in these provinces. Commercial exploitation may not be expected to increase greatly so long as cheap petroleum and eastern coals are available in the industrial centers. Nevertheless the great known reserves of coal afford us assurance that the country need have no fear of a fuel famine for centuries to come.

The Pacific Coast Province includes the coal fields of Washington and Oregon. The fields are small, the coal is not of high quality, and mining conditions are difficult Exploitation must meet competition of coal from Alaska and crude oil from California at low shipping rates. Domestic demands are light because of the mild winter temperatures characteristic of the Pacific Northwest The railroads have greatly expanded their electrification programs through development of the water-power resources of that part of the country, and thereby they have reduced their demands for coal The outlook for the coal mining industry there is for recession rather than expansion in the near future.

Geographic significance of the distribution of coal in the United States—North America is unique in that it is the only continent having the deep interior known to be richly endowed with coal The other continents have their greatest known stores of coal near their seaboards, while their interiors are relatively deficient. This is particularly true of South America, Australia, Africa, and, as far as we know, of Eurasia. Furthermore, there are larger reserves of coal in North America than in any other continent Among the nations, the United States ranks foremost in known reserves, and it is further favored by such widespread distribution of workable coal beds that every section is within easy reach of some field

Among the various economic effects of the distribution of the coal fields, two outstanding ones deserve emphasis First, the coal fields of the eastern United States are more than 200 miles from tidewater ports. Railway transportation over rugged country from mine to port adds materially to the cost of the coal at the seaboard This factor is a handicap to the development of a large export trade because of the competition of European coals mined near tidewater, where land transportation costs are slight. Secondly, the wide distribution of coal in the interior has furnished the power necessary for industrial and agricultural development there such as no other continent has ever experienced. The transcontinental

railroad systems have natural refueling stations at relatively convenient intervals throughout their courses Had there been coal along the coasts but not in the interior, the costs of hauling agricultural products to seaboard markets would have been prohibitive and agricultural prosperity could not have been achieved. Without agricultural prosperity, industrial growth in the interior would have been impossible Without the great markets of the Middle West and the Rockies, the industrial progress of the east would have been seriously curtailed. While, of course, other factors are also involved, to the

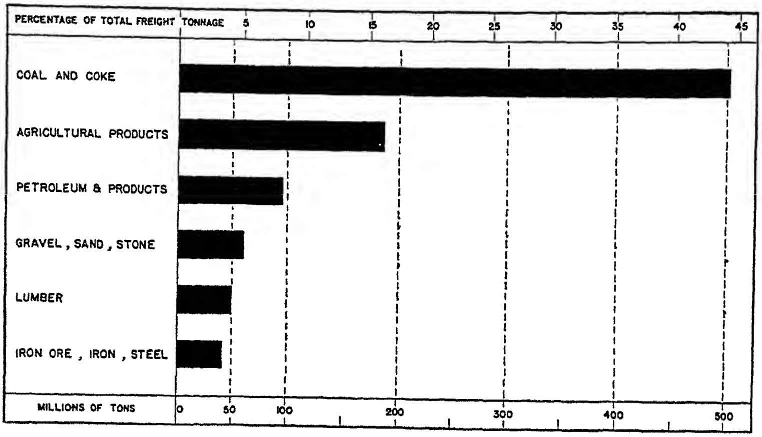


FIG. 101.—Graph showing the importance of coal and coke as railroad freight in interstate commerce in the United States, 1933. (Source of data: *Freight Commodity Statistics*, Bureau of Statistics, Interstate Commerce Commission, Washington, D C)

coal fields of the interior—from Ohio to Colorado—credit must be given for much of the energy and industrial progress of the United States The widespread distribution of this great power resource is a geographic factor of major importance in accounting for the high agricultural and industrial achievements of the empire beyond the Alleghenies.

Coal production in the United States.—The total annual production of coal in the United States averages somewhat less than 600,000,000 tons. Pennsylvania anthracite accounts for about 12 to 14 per cent of the total In the output of bitumin-

ous coal, Pennsylvania holds commanding lead, with West Virginia in second place; Illinois and Kentucky usually rank third and fourth, but either may outrank the other; Ohio has rather consistently held fifth place The importance of coal to the development of centers of heavy industry, such as Pittsburgh, Cleveland, Detroit, and Chicago, is evident.

United States foreign trade in coal.—Exports of American coal constitute but a small fraction of the total output, usually between two and six per cent. Ordinarily Canada takes nearly 95 per cent of the anthracite exports and from 80 to 90 per cent of the bituminous exports. Geographical proximity of the American coal to the most densely populated part of Canada, and the remoteness of the largest Canadian reserves, are the factors which favor importation of coal from the United States. This trade has been built up on the sound basis of supply and demand, and its continuance should be encouraged because it is advantageous to both countries

American exports to European markets are small, as should be expected, since European coals are mined near the seaboard or where water routes are available from the interior Inasmuch as coal is a bulky product in proportion to value, low cost transportation from mine to market is a decided advantage to trade

The Caribbean lands are export markets for American coal, but their needs are not great. In the larger South American markets competitive conditions exist, and American exporters find it difficult to meet prices offered by Europeans, particularly the British. On the whole, Brazil is a better market for American coal than is Argentina, largely owing to differences in the export trade of the two countries. The United States is the greatest customer for Brazil's foremost export, coffee. Hence southbound freighters carry coal to her at relatively low charges Argentina on the other hand exports grain and meats, for which England is an important market. British ships outward bound quite naturally carry coal as part of their cargo, because Argentina's other imports are commodities of high value in proportion to weight, such as electrical

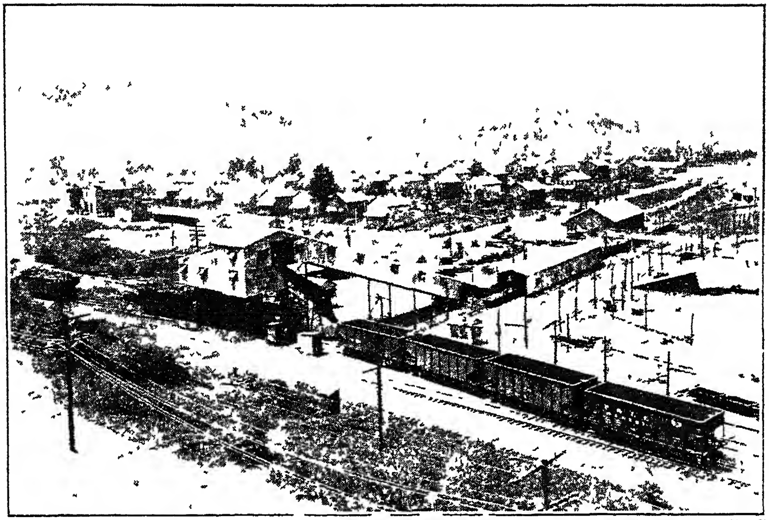
goods, machinery, chemicals, and textiles, which demand less cargo space than do her bulky exports of grain, wool, and hides.

On the whole, export trade in American coal may not be expected to increase There are no indications of expanding markets. Foreign competition and increasing use of petroleum fuels for bunkering purposes are factors which point to decreasing rather than increasing demands for American coal for marine purposes as well as for exports.

Small quantities of coal are imported by the United States. This is true of New England, where some coal has been brought in from Nova Scotia because of nearness. Occasionally vessels returning from overseas bring cargoes of coal at very low freight charges because they are in need of ballast. Some coal is imported from Australia and Japan to the cities along the Pacific Coast, but the total quantities are small and the industrial significance of these imports is virtually nil. The United States is so favored by its own stores of widely distributed, high grade coals that imports of coal have but little economic basis in any section, and therefore they are likely to remain slight.

Some problems of the American coal industry.—The coal mining industry of the United States is capable of much greater production than the demands call for, hence unemployment, even in normal times, is a grave problem The number of days a year on which the coal mines operate is usually below 200, and in some years it is much less. Nearly 700,000 men are affected by the periods of idleness which annually occur, varying only in degree in different states and during various years. This situation presents one of the most pressing problems in economic adjustment which face the nation Inasmuch as the men employed in the coal mining industry must be supported during the entire year, the necessary cost of production per day is excessive if only half of the time is used Eventually this condition must be changed No industry can support a large number of idle men. Inefficient mines, or those without good marketing facilities because of remote-

ness, must be closed and remain so until economic demand for their output develops In many instances that may be decades hence The laborers dependent on those mines should be provided with other work The general estimate that 25 per cent of the coal miners can be classed as surplus labor is probably about right. The solution must be found by opening up to them other avenues of employment Readjustments are always difficult, but in a changing society they are inevitable It seems only fair that the cost of such readjustments should



Courtesy, United States Bureau of Mines, Washington, D C

Fig. 102.—Part of the surface plant of a Pennsylvania drift mine and company village.

be borne in part by the social system which makes them necessary

Coal production in Europe.—There are three major areas of coal production in Europe; namely, Great Britain; the northwest continental district, which includes northwest Germany and extends through Netherlands and Belgium into northeast France; and the Silesian district of southwestern Poland, Germany, and Czechoslovakia. Secondary centers are in the Saar district near Alsace, in the Donetz Basin of southern Russia, and in the smaller producing areas of Italy, Spain, and south-

ern France The United Kingdom and Germany are the two leading coal-producing countries of Europe. Although the annual output in tons is greater, about 50 per cent of the coal production of Germany consists of lignite, of much lower heat value than bituminous coal and, therefore, on the basis of importance to industry the production of the United Kingdom slightly exceeds that of Germany.

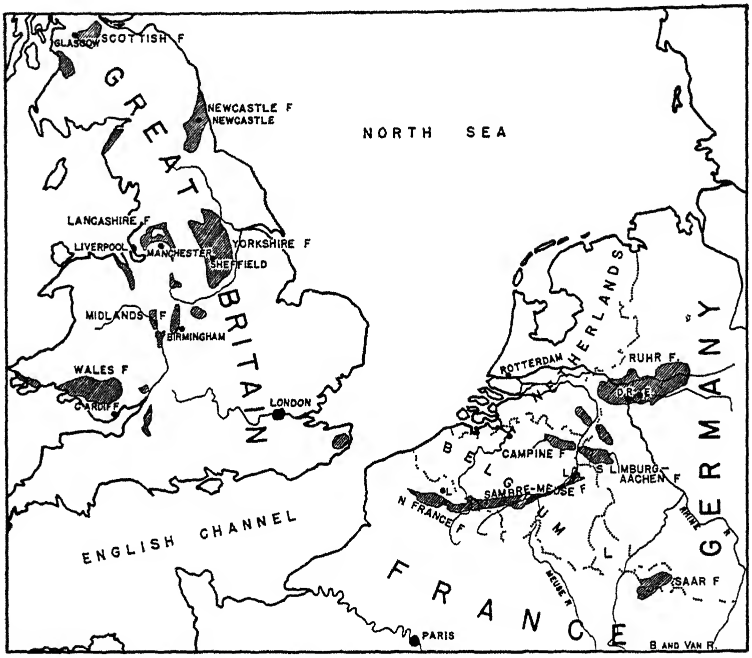
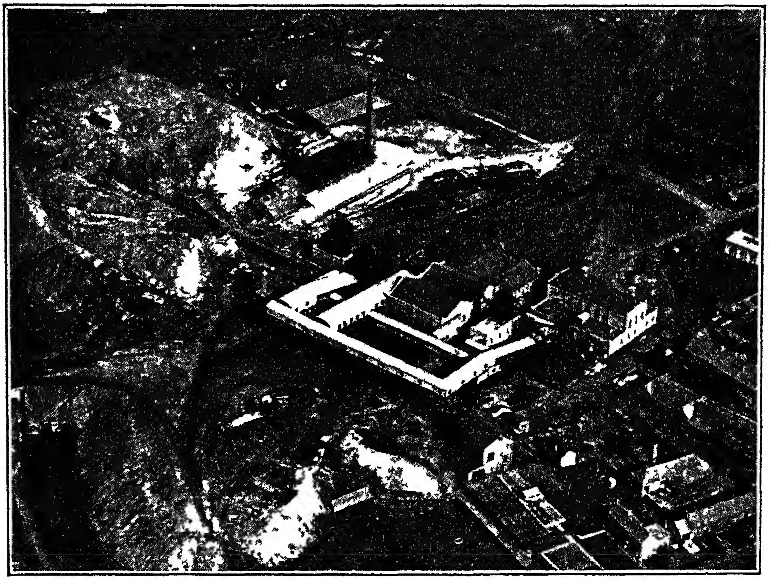


Fig 103.—Principal coal basins of northwestern Europe.

Coal is the basis of British industry and is the most important bulky export in British foreign trade. Since Britain has but little water power and neither petroleum nor natural gas, she must place complete reliance upon coal as her chief fuel resource for power purposes. The keen competition of other fuels which coal is meeting in all parts of the world is especially felt in Britain because of the large number of workmen who suffer by curtailment of coal production With labor compelled to produce at low wages and confronted by long periods of un-

employment, industrial progress is impeded and the purchasing power of a large percentage of the British laboring classes is seriously reduced. British industrial life may, therefore, be said to exist largely on a coal basis, and it must adjust itself to competition with petroleum and water power in other countries of the world This is not easy to accomplish.

As a result of the war settlement, Germany suffered not only temporary loss of the Saar coal field but also permanent loss of



Courtesy, Seghill Colliery Co, Ltd Photograph by Surrey Flying Services, Croydon, England

Fig. 104 —Surface plant of modern British shaft mine in Northumberland. Note colliery and hoists in center of picture, culm piles at left, transportation facilities in upper right and workers' dwellings in lower right

a considerable portion of the Silesian fields. The latter was a severe blow, because the reserves are great and industrial demands were rapidly expanding. She retained, however, the most valuable of her deposits in the Ruhr district, and this constitutes the greatest natural resource of Germany for power production. These coal deposits are extensive, of high quality, and they present comparatively simple mining problems. Coke made from Ruhr coal is in demand for smelter operations

throughout northwestern Europe, and it furnishes the essential basis for the extensive German iron and steel industries Germany has also enormous deposits of brown lignite, a coal which has long been valuable for domestic purposes and is now attaining industrial significance through its use in generating electricity for lighting and manufacturing purposes Furthermore, it promises to become of much greater importance in the near future because of its utilization through improved chemical processes The recently discovered Bergius process of hydrogenation makes it possible to convert coal into liquid fuel, and if that can be accomplished on a profitable basis, there is great likelihood that lignite will become one of the major power resources of Germany The outlook for the coal industry is, therefore, highly favorable, and the future gives promise of even greater progress than has been made in the decades past.

Coal production in other continents.—While great reserves of coal are known in Asia, particularly in Siberia and China, and there are fairly extensive deposits in Australia and South America—Japan, China, and India are the only countries where large commercial development has occurred The average annual production of each of these countries is about 20,000,000 to 30,000,000 metric tons, with Japan usually in first place. It is significant that Japan is the most industrialized of any of the countries of the Far East and the most progressive; coal furnishes most of the power which has made this industrial progress possible Development in Australia is handicapped by lack of both labor and markets. Largely because of the youthfulness of the country, industrialism has not reached the stage of development common in some of the older nations As demand increases, the coal mining industry of Australia may be expected to keep pace, but there seems slight prospect of any rapid progress for some time to come

South America has some known reserves, widely scattered and but little exploited. Inasmuch as coal can be imported at relatively low cost and the petroleum industry is expanding, the near future does not seem favorable to any important de-

velopment of the South American coal industry Capital finds more profitable employment in other fields than searching for coal beds and opening up mines.

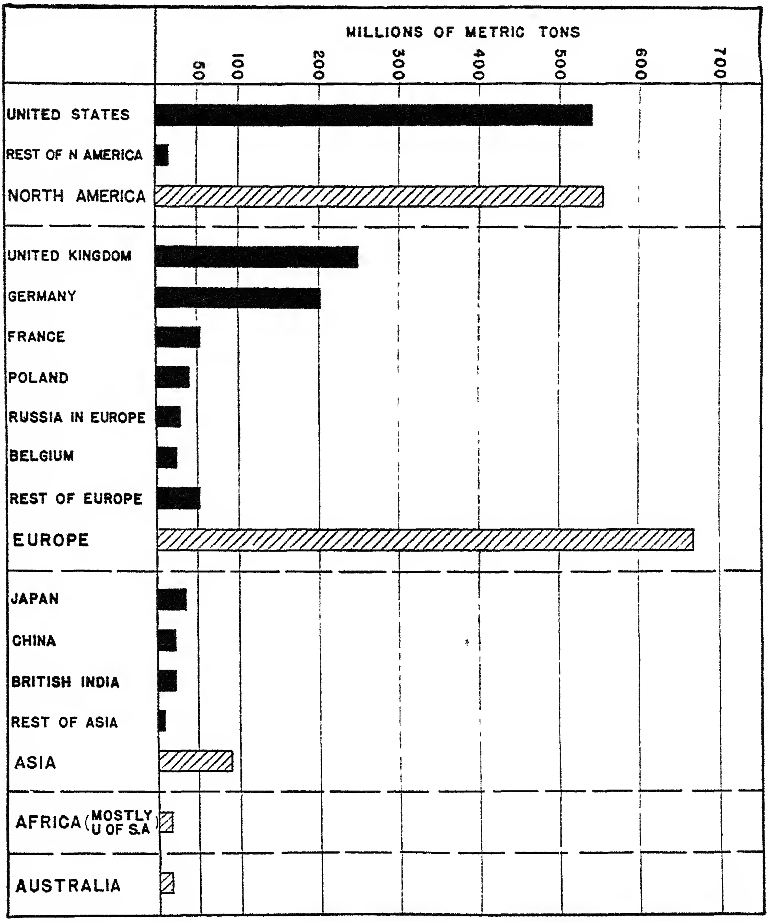


FIG. 105.—Average 1926–1930. Coal output of principal producing countries. (Source of data *Mineral Resources of the United States*, Bureau of Mines, Washington, D C)

In the world at large, North America and Asia lead the continents in total reserves Among the countries, the United States, Canada, Russia, and China outrank all other nations in their stores of unmined coal In production, however, the

United States, the United Kingdom, and Germany are the leaders, and the present outlook is for a continuance of this leadership, although Russia may advance into a comparable position in the near future.

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CHAPTER XI

The Petroleum Industry

THE high place which petroleum holds in modern industrial activities is indicated by the fact that it is now one of the five commodities produced in the United States which usually exceed the billion dollar mark in value of annual output The significance of petroleum is also indicated by the great variety of products which are made from it and by the multitude of activities which have been developed in connection with it Among the most familiar products may be mentioned the following: gasoline, kerosene, fuel oils, lubricating oils, greases, asphalt, and coke While this list may be considered as representative of the principal products of petroleum, many others have come into such common use that they are recognized as essentials in our present standards of living Petroleum, as well as coal, now furnishes the raw material for a rapidly growing chemical industry, the products of which enter into numerous avenues of industry. As examples of such products we may name paraffine, vaseline, medicinal oils, benzene, and dyestuffs.

Economic importance.—Nevertheless, the greatest industrial significance of petroleum is its use as fuel and lubricant for automobiles, trucks, and airplanes. The motor industry has reached such importance that its progress and prosperity are looked upon as keen business barometers When motor car production and sales are expanding, a host of other lines of activity reflect the glow of prosperity, among them coal mining, steel manufacture, copper mining and fabrication, and the manufacture of rubber tires.

Not only in the United States, but in many other countries of the world, petroleum has become an industrial giant. Its

importance to national defense as well as to industrial progress was keenly demonstrated in the World War, and the advantage which the Allied forces had in petroleum supplies was an important factor in determining the outcome of that struggle That leading statesmen recognized this was shown by the attention they paid to petroleum and the forcefulness of their utterances on this subject Soon after the entry of the United States into the war, President Wilson sought and obtained the active coöperation of the petroleum companies In England, Ambassador Page, in announcing this cooperation, is reported to have said that "Standard Oil, by order of the President, was harnessed to the victorious chariot of the Allies." Later on, when the Armistice was declared, Lord Curzon in happy mood exclaimed that "the Allies floated to victory on a sea of oil"

The industrial significance of petroleum, as well as its importance to national defense, became so generally appreciated as a result of the experiences of the World War that during the years immediately following, the contest for petroleum concessions developed into one of sharp international rivalry During the past two decades representatives of the progressive industrial nations have ransacked the remotest sections of the globe in search for evidences of petroleum possibilities, with the result that individuals or corporations have obtained exclusive rights to explore for oil in nearly all lands wherever potentialities are believed to exist

Of little commercial importance prior to 1860, the petroleum industry advanced from obscurity to front rank position among the business enterprises of the world before the close of the nineteenth century

Historical sketch.—Although commercial development is of relatively recent date, the existence of petroleum has been known for many centuries and some use has been made of it since earliest historic times. The bricks of the Tower of Babel were probably bound with asphalt, a residue from the oil seeps of Mesopotamia There seems no question that the ancient Persians were familiar with petroleum and that they made use

of seepages which even then were known to exist in that country. The seepages along the shores of the Red Sea were probably the sources of the petroleum used by the ancient Egyptians in developing the art of embalming to such high degree of efficiency The pitch (or *brea*) from these seepages is thought to have been used by the Phoenicians in caulking their wooden vessels, and some go so far as to state that without this splendid caulking material, they might not have attained their well-known proficiency in navigation.

During many centuries, seepages found in various places in the world were the only sources of petroleum Medicinal value

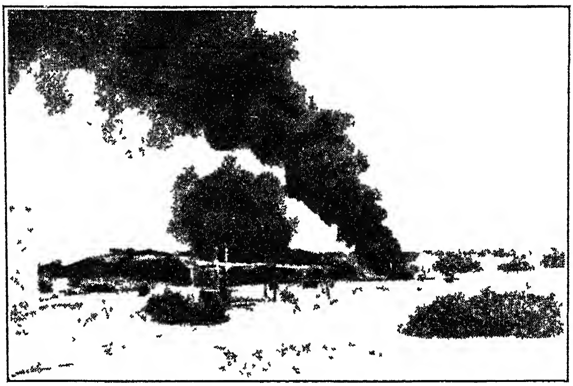


Photo by N A B

Fig 106.—Burning crude oil in open vessels to a tar-like residue known as "brea" for use in caulking wooden boats Santa Elena Peninsula, Ecuador.

was early attributed to the oil, and even its potential use as a fuel and lubricant had become recognized long before it attained commercial importance The springs near Baku, on the banks of the Caspian Sea, have yielded oil for 2,000 years or more Marco Polo, in the thirteenth century, noticed the oil seeps at the southern base of the Caucasus Yule, in his "Travels of Marco Polo," refers to a fountain there from which "oil springs in great abundance. This oil is not good to use with food, but 'tis good to burn, and is also used to anoint camels that have the mange"

The presence of oil seeps and the growing use of oil in lamps

and for ointments led to the making of hand-dug wells in order to obtain larger production In most places these wells were not very successful because the seepages came from openings in hard rocks But in other districts, notably Burma, the seeps came through soft rocks, and hand-dug wells served to increase the output substantially. "Rangoon oil" was an article of commerce in London early in the nineteenth century. Hand-dug wells were numerous in Rumania also Beginnings of oil refining to produce kerosene and lubricants had been made before there was an American petroleum industry.

In America, even before the coming of the whites, the Indians used petroleum internally as a medicine and externally for toothache, headache, and sprains Before 1670, Jesuit missionaries had reported oil springs in several localities in western New York and Pennsylvania. Although the presence of oil was known early, its uses were not well understood and demand grew slowly. Before the middle of the nineteenth century, however, the use of oil had expanded to such an extent that the price for the small available supplies exceeded $20 per barrel. This condition attracted attention, and companies began to be formed for the exploitation of the "rock oil." Since it was a field entirely new, all the techniques of exploitation and refining had to be learned Drilling through hard rock was the first problem to be solved.

In 1859, near Titusville, Pennsylvania, Colonel E L. Drake rigged up a crude drilling apparatus based upon the principle of crushing the bedrock into pieces by successively raising and dropping a heavy iron rod equipped at its lower end with a sharp bit By this triphammer method he drilled his well to a depth of 69 feet, where it was found to yield 25 barrels of light oil per day. This was the first well to be drilled mechanically for the express purpose of obtaining petroleum The exact location of the well was determined by seepages along the banks of Oil Creek nearby; oil from such seepages had been gathered and used for medicinal purposes, some of it having been exported to England for sale in the chemists' shops, or drug stores. At first the petroleum produced by the discovery

of hydrogen and carbon chemically combined in varying proportions Petroleum is, therefore, a mixture of liquids and gases and this mixture may contain so many different kinds of each that the abilities of the chemist are tested to the utmost in order to recognize them and to separate any one of them from all the others

The large number of different possible mixtures gives rise to numerous kinds or grades of crude oil In a general way it may be said that the value of petroleum rises as its density decreases; that is, the lighter oils are richer in desirable products than are the heavier oils There is a broad tendency for the density of the oil to vary with the carbon content Heavy oils have a relatively high percentage of carbon and a low percentage of hydrogen, whereas in the light oils the reverse conditions hold true, the percentage of carbon being small and that of hydrogen large Furthermore, light oils are usually much richer in gasoline and light naphthas than are the heavy oils, a fact of great importance in determining market grades

Petroleum varies in color from light straw to almost black Some kinds are greenish, others amber-colored, and some even rich wine-red In general, the lighter colored, greenish oils are characteristic of high grade crude, whereas the brown to black colors are characteristic of the heavier grades Crude oil is classified into three groups, with respect to the residue which results upon evaporation or refining, namely, paraffine base, asphalt base, and mixed-base oils The paraffine base oils are ordinarily lighter and more fluid than are the asphalt base oils.

The density is expressed in terms of specific gravity, or in terms of its equivalent on the Baumé scale Specific gravity, of course, refers to the ratio of the weight of a given volume of the oil to the weight of the same volume of water under standard conditions. The temperature used as the standard for petroleum is, in most cases, 15° Centigrade, although 45° Fahrenheit is sometimes used. Specific gravity of crudes varies from .77 to 1 00, but ordinarily ranges between 82 and 94. The direct specific gravity scale is open to the objection that it deals with fractions and that the numbers are neither read nor

remembered easily Therefore, an arbitrary scale, known as the Baumé, is employed, and petroleums are usually designated in terms of Baumé rather than in terms of specific gravity On the Baumé scale, specific gravity 1 00 is read as 10°. Oils are tested by means of hydrometers constructed for use in liquids lighter than water, and therefore the readings are given in integral numbers larger than 10 The lighter the liquid, the deeper into it the hydrometer will sink, and therefore the reading shown by the contact of the surface of the liquid will be correspondingly higher. Oils nearly as heavy as water have readings only slightly larger than 10°, whereas those which are light have much higher readings In common trade usage, crude oils which give a Baumé test below 20° are known as *heavy,* whereas those which test above 30° are known as *light* oils.

Petroleum refining has been improved so much in recent years that it can no longer be called a process of mere distillation Formerly it was generally understood that "gasoline was gasoline," now we know that various grades are essentially different. Care in supplying specific qualities of gasoline for use in motors operating under different mechanical and weather conditions has become a characteristic of the trade The improvements in the technique of refining whereby higher quality products are obtained have been made hand in hand with progress in making more complete use of crudes which were formerly deemed undesirable Heavy oils can now be converted into light oils, the basic principle of the process being to heat the oil under pressure in the presence of free hydrogen. Through chemical absorption of the hydrogen, the petroleum is converted into a lighter grade, and the quantity of gasoline obtainable is thereby increased. This is the fundamental principle underlying the hydrogenation process. Through these and other advances in refining, the percentage of gasoline extracted from the crude has more than doubled in the last twenty years. Had this not been accomplished, we would be faced with gasoline shortage in the United States in spite of the enormously increased production.

Sources of supply.—Most of the petroleum of the world occurs in the sedimentary rocks, especially in sandstones, conglomerates, shales, and limestones Open textured sandstones are perhaps the most common reservoirs, although notable production, as in western Ohio and in Mexico, is sometimes obtained from porous or cavernous limestones. It is rarely found

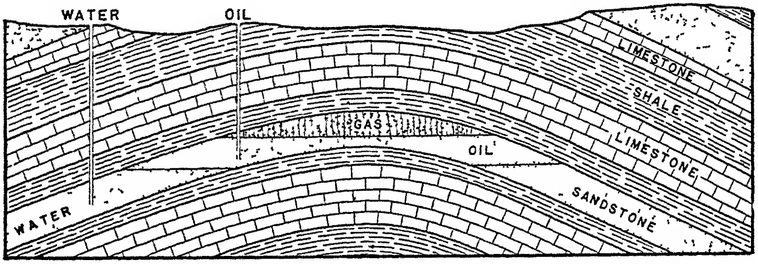


FIG. 108.—Diagrammatic cross-section of a dome or anticline. Shale cap rock serves to seal gas, oil, and water in the underlying sands; distinct horizons due to differences in specific gravity.

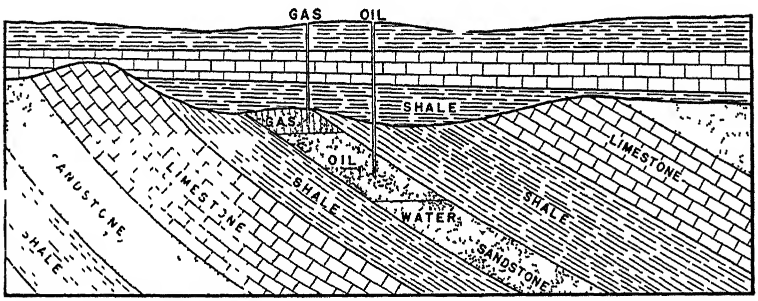


FIG. 109.—Diagrammatic cross-section to illustrate gas, oil, and water horizons in a monoclinal structure. The tilted beds were bevelled in an early erosion cycle; then subsidence with deposition of overlying beds was followed by broad uplift causing present plain. Accumulation of gas and oil sealed in old, tilted strata by later shale cap.

in igneous rocks, and in the few cases that have been discovered, the migration of the petroleum from sedimentaries into those localities has been clearly accounted for. Petroleum usually occurs in strata, varying in structure from steeply folded and much faulted to a position so slightly inclined as to be hardly distinguishable from the horizontal. Anticlines are perhaps the simplest and best known folds favorable for petroleum ac-

cumulation. Where that type of structure is found in petroliferous areas, natural gas may occur in the apex of the anticline, petroleum on the upper flanks, and water at the lower levels. The same sequence has been observed repeatedly in other types of structures and in the various oil fields of the world, wherever studied.

Terminology used in describing distribution of petroleum.—It is rather unfortunate that the terminology used in describing the distribution of petroleum is not clearly defined The great popularity of oil has made it a common subject of

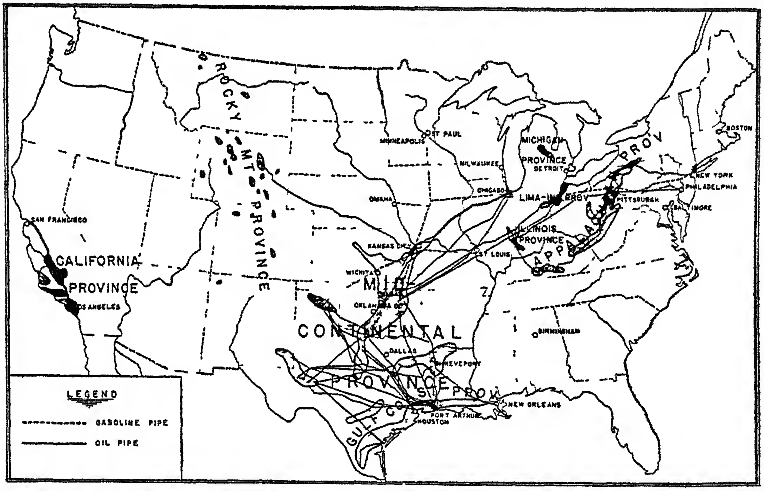


Fig. 110.—Map of oil provinces and principal pipe lines in the United States

conversation; the terminology has been determined, therefore, by the language of the layman, and this varies greatly in different sections From a technical point of view, it might be suggested that the larger unit areas of petroleum production should be known as *provinces* and that subdivisions should be named in descending order as *fields, districts, pools,* and *wells,* each representing a unit subdivision of the preceding. This type of terminology has been suggested by some writers, but since no such scheme has been widely accepted we must face the facts; that is, that *field* as used in the petroleum industry may refer to an area that covers portions of several states or it may refer to

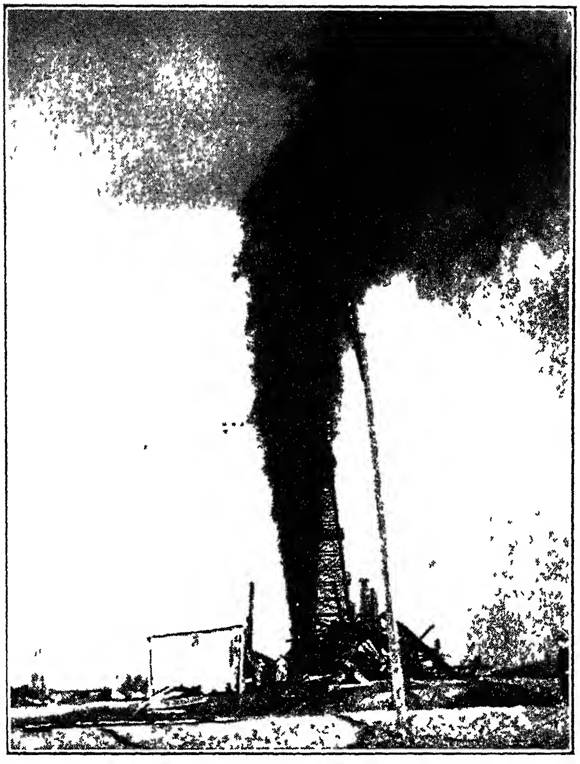
an isolated center of production where only a fraction of a section of land may be involved As used in this discussion, the term *province* is limited to the largest aggregates of producing areas, and the term *field* is applied only to the larger subdivisions of the provinces

Distribution of petroleum production in the United States: *The Appalachian Province.*—The first great oil field to be developed on a large scale was the one which extends from southwestern New York through Pennsylvania and eastern Ohio southward into Tennessee Oil had long been known to exist in seepages along some of the creeks of northwestern Pennsylvania, and for many years the crude had been skimmed from the surface of the water and used for medicinal purposes In some instances people digging wells for water had penetrated oil soaked muds and sands, but in such cases they considered themselves unfortunate because the oil ruined the chances of obtaining good drinking water there

With the success of Drake's discovery well in 1859, all this was changed and a rush of drilling followed Within a year several hundred wells had been drilled; most of them were dry holes but some were fairly good producers The first flowing well was struck in June 1861, with a daily output of over 300 barrels of oil In September of the same year the first "gusher," flowing 2,500 barrels per day, was brought in. Such results were wholly unlooked for, and people were then willing to believe anything The first oil boom was on, and the buying interest in proposed wells became a public craze But the boom was of short duration; the market soon became flooded with oil. The price dropped from above $20 per barrel to almost zero. Thousands of barrels are reported to have been sold as low as five cents per barrel Thus, within three years after the discovery well the young petroleum industry had felt the thrill of boom conditions and the gloom of depression Thereafter, however, it steadied, and the Pennsylvania oil furnished the foremost supply of crude for an ever growing American industry.

The maximum production of the Appalachian Province was

reached in 1891, when more than 33,000,000 barrels of oil were obtained. Since that time there has been a slow decline, but recent revival of production through deeper drilling, improved methods of pumping oil, and the discovery of new pools in the southern portions of the province has brought it up to nearly 30,000,000 In general, the Appalachian Province is notable for



Courtesy, United States Bureau of Mines, Pittsburgh office

Fig 111.—A "gusher" flowing wild. Not only much oil was wasted but great damage was done to crops and dwellings by covering them with oil spray. With modern methods such accidents can usually be prevented.

its long period of life and its relatively steady production. Some of the older portions now produce less than an average of one-fourth barrel per well daily, and the average production of all wells in Pennsylvania now operating is less than three-tenths of a barrel per day

The oil is high grade, ranging from 40° to 45° Baumé in the eastern portions of the province and around 35° Baumé in the western portion. It is a paraffine-base crude characterized by low percentage of residue, and it is free of sulphur, easily refined, rich in the light constituents, and contains high grade lubricating stock These favorable properties cause the oil from this province to be ranked exceptionally high, and the term "Pennsylvania crude" has come to stand as representative of the world's best oil Because of its high quality and its nearness to the great marketing centers, it is the highest priced crude in the United States.

The Ohio-Indiana Province.—The Ohio-Indiana Province extends in a general southwesterly direction from near the west end of Lake Erie almost to Indianapolis The province lies on the west flank of the Cincinnati arch, or anticline, the crest of which separates it from the Appalachian Province to the east Production, which began in 1884, reached its maximum in Ohio in 1896 and in Indiana in 1904. Since then decline has been steady, and there is no indication that any revival may be expected. The oil is of paraffine base, fairly light, averaging 30°-35° Baumé, but is somewhat difficult to refine because of sulphur and water content In the early stages of development the sulphur gave much trouble, but improved methods of refining have largely overcome this difficulty. The area has been quite thoroughly exploited, more than 60,000 wells having been drilled before 1931.

Notwithstanding the favorable location of the province and the relatively high quality of the oil, the crude usually sells considerably below that of the Appalachian fields. Although commercial production is likely to continue for many years, the declining trend marks it as a dying province, with complete exhaustion of the available oil but a matter of time.

The Michigan Province.—Michigan was not listed separately in the statistical record until 1925, although some oil had been produced many years earlier. With important discoveries at the close of that year, the state was credited with a production of four thousand barrels. Up to the close of 1927 the Saginaw

field produced nearly the entire output of the state, but since then the Muskegon area in the western part has attained considerable importance It is possible that Michigan will show greater production in the next few years, but it does not seem probable that it will reach the large production which has characterized the other major fields of the United States.

The Illinois Province—The petroleum producing area of Illinois is mostly in the southeastern part of the state, the field extending into the adjacent portion of Indiana. Commercial production began in 1905 and expanded rapidly to 33,000,000

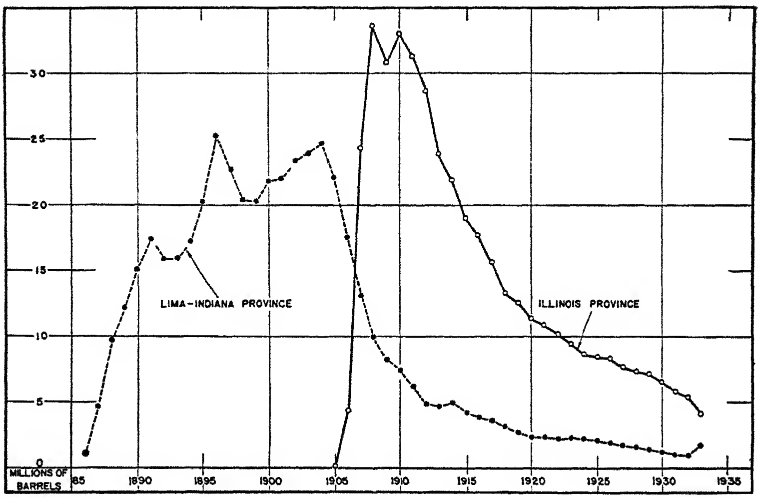


Fig. 112.—Graph showing trends of production in the Lima-Indiana and the Illinois oil provinces.

in 1910, since which time there has been a slow and steady decline to a present yearly production below 6,000,000 barrels. Deepening of wells, although giving somewhat increased production in some areas, has not achieved the results hoped for.

The petroleum of Illinois is mostly of paraffine base, tests above 30° Baumé, is sulphur free, and is easily refined. Since the content of natural gasoline is, however, relatively low, only about 15 to 20 per cent, the crude has a market value below what might be expected for oils of such high gravity.

The outlook for the future does not promise any material im-

provement in the situation unless new pools are discovered, and this seems rather doubtful at present The production of the Illinois region may be expected to decline slowly unless sharp increases in the price of crude should make more expensive processes of production economically practicable

The Mid-Continent Province—Included within the Mid-Continent Province are the petroleum producing fields which extend from near Kansas City southward across Kansas and Oklahoma, into Texas, and thence eastward across northern Louisiana and southern Arkansas. Comprising the outer fringes of this vast area are the producing fields of central Kansas, the pan-handle areas of Oklahoma and Texas, and the more recently discovered production areas of west-central Texas. Thus defined, the province is by far the largest, most productive, and most important oil producing area in the world Large scale commercial development began about 1906 Since then progress has been steady, production mounting year by year with only slight interruptions, and there is every reason to believe that the maximum output has not yet been reached.

The Mid-Continent Province produces practically all grades of oil; some have paraffine base, others mixed base, and still others asphalt base. Some are almost as heavy as water, while others are as light and high grade as those of Pennsylvania The complexity of structural conditions, the probably different sources of origin, and the vast extent of the province are the factors which are responsible for the pronounced diversity in the quality of the oils. The petroleums from the shallow wells south of Kansas City are heavy, of asphaltic base, low in gasoline content, and of little lubricating value On the other hand, those from the deeper sands at Augusta, Kansas, or Cushing, Oklahoma, are light (35° to 40° Baumé) and contain a high percentage of gasoline and light lubricants These are illustrations of the variety of quality shown by the crude from the Mid-Continent Province and serve to explain the basis for the wide range of prices which prevail.

The Mid-Continent Province is noted also for the wide diversity of capital interests represented there Since it was

the meeting ground of East and West, North and South, it was but natural that capital from all these sources should there become interested in large scale development, and as a result more different companies are exploiting oil in this province than in any other area in the world. The well-known Standard Oil corporations of Indiana, New Jersey, Ohio, and California are

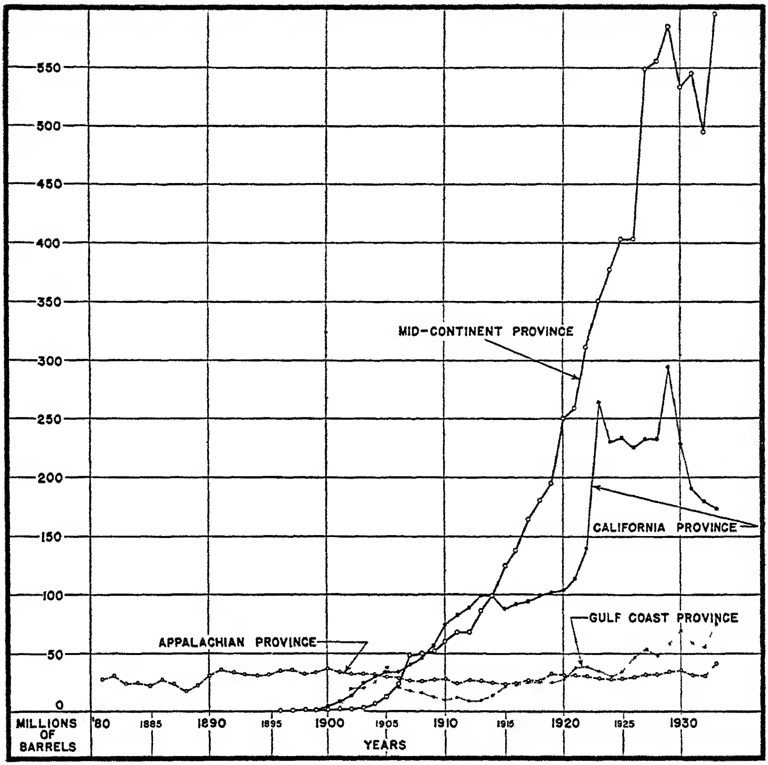
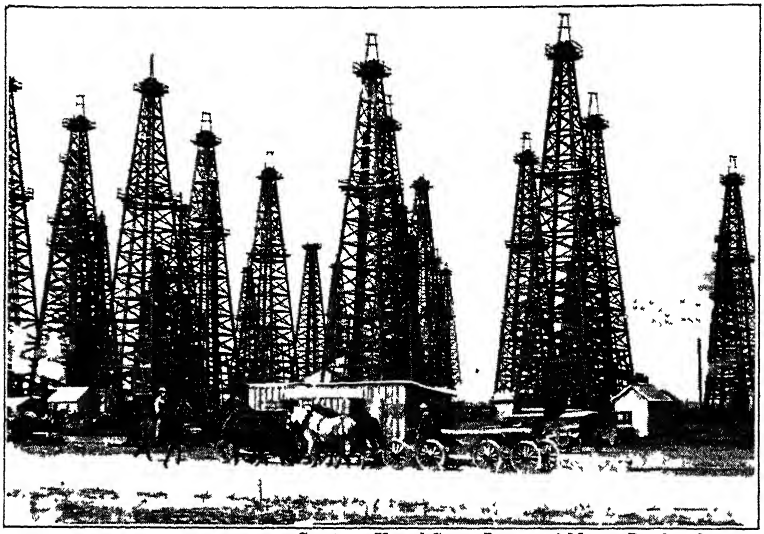


FIG. 113.—Graph showing trends of production in the Appalachian, Gulf Coast, California, and Mid-Continent oil provinces.

prominent, and all the large independent companies of the United States have extensive holdings. Important foreign companies also are represented, particularly the well-known Royal Dutch-Shell group. Contrary to popular opinion, no monopolistic condition prevails. Production, transportation, refining, and marketing are all on competitive bases, and the only

semblance of any general agreement along these lines is the movement toward limiting production to legitimate market demands. Continued overproduction in the United States during a period of years has rendered control of output necessary In earlier years any agitation toward arbitrarily curtailed production would have raised loud and long protest in many sections. Recent developments, however, have convinced people that production in proportion to demand makes possible the highest prosperity for all, and that long-sustained production



Courtesy, United States Bureau of Mines, Pittsburgh office

Fig. 114.—Scene of activity in the development of the deeper zones of the Spindletop, Texas, oil field.

at a rate greater than the market can absorb is unsound economic practice and wasteful of a great natural resource.

While the potential production of the Mid-Continent Province is enormous, we must not be deceived into thinking that the reserves are inexhaustible. That the province will continue to be the major producing area of the United States seems certain, but as exploitation increases, the amount in reserve decreases in like degree. Oil production is a mining activity; oil taken out is not replaced. In time even the great Mid-Continent Province must face declining output

The Gulf Coast Province.—The Gulf Coast Province includes the producing areas of the coastal plains of Texas and Louisiana. Production was discovered in 1900 and rose steadily to its first prominent peak in 1905, since which time declines and revivals have been characteristic. The province ranks third in the United States, and there is good reason to believe that important output will continue for a long time.

The oil occurs in association with rock uplifts or domes. The early discoveries were made by drilling on the low domes, which appeared as hills rising a few feet above the surrounding flat plain. In recent years production has been obtained through the discovery of buried domes not shown by the surface topography. Improved methods of prospecting have been quite successful in locating such structures and, therefore, scientific subsurface study is being pushed with vigor Various theories have been proposed to account for these domes some domes are believed to have resulted from salt accumulations, while others may have resulted from igneous activities whereby crystalline masses were pushed upward into the overlying sedimentaries.

The crude oil produced in the Gulf Coast Province is heavy, of asphaltic base, and not so valuable for refining purposes as the lighter oils farther north. Much of the oil contains but little natural gasoline and runs high in both carbon residue and sulphur content. Crude of this kind is sold for fuel purposes. Other kinds contain excellent bases for the manufacture of heavy cold-test lubricants, and their value depends more upon the lubricating stock than upon the gasoline content. In recent years the improved methods of cracking heavy oils through distillation under high pressure have been important in giving some value to such oils as sources of gasoline On the whole, however, one of the chief uses for the Gulf Coast oil is for marine fuels, and an extensive market has been developed for it as bunker oil for steamships

The Rocky Mountain Province.—The Rocky Mountain Province is a convenient geographic designation for a tremendous area which includes many types of structures and

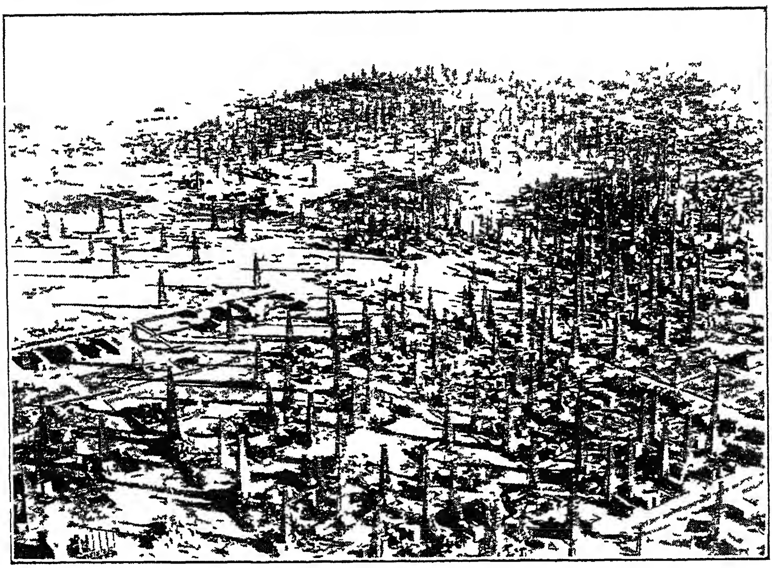
topographies as well as varied types and qualities of petroleum. It extends from the Canadian border to New Mexico, the most important producing states being Wyoming and New Mexico, the latter having recently displaced Montana from second place among the Rocky Mountain states in oil output. In general, the oils of the Rocky Mountain Province are of the light density group, although several pools yield those of heavy asphalt base.

In view of the extensive area included in this province, its possibilities are great, although drilling campaigns have not discovered the bonanza fields so eagerly desired by promoters. Except in New Mexico, the province has been declining in production during the last few years. This trend does not indicate that the possibilities have been exhausted, it is largely a response to curtailed exploitation due to the general situation of over-production in the United States. The future outlook, therefore, is one of uncertainty; as prices of crude become substantially higher, there is no doubt that a more vigorous search will be made, and important new producing areas may then be discovered.

The California Province.—The California Province ranks second in annual output of petroleum in the United States. It consists of two principal producing areas, the older being in the southern part of the San Joaquin Valley, the younger in the Los Angeles Basin. The existence of oil in both areas has been known for many years because of seepages found in various places and the presence of asphalt in rock exposures. It is claimed that refined oil was prepared from seepages near Santa Barbara in 1857 and that asphalt was mined in Ventura as early as 1866. Wells were drilled for oil in 1884, and the first successful wells in the San Joaquin Valley were completed at McKittrick in 1887. Inasmuch as local demands were small and eastern markets were remote, development was slow until about 1900. Then large scale production began in the upper portion of the San Joaquin Valley, and from 1903 to 1915, California held the lead in petroleum output. Since 1915 first

place has been held at various times by Oklahoma, Texas, and California

The oil pools of California are characterized by high gas pressure, and therefore the flush output of wells is high The quality of the oil varies from light to heavy in different pools, some being of exceptionally high quality, but for the province as a whole asphaltic oils predominate In spite of low prices for such oils the great flush production long ago made wells highly profitable and led to veritable orgies of drilling. Enor-



Courtesy, Youngstown Sheet and Tube Co, Youngstown, Ohio

Fig. 115.—The Signal Hill oil field near Los Angeles. An illustration of uneconomic development. Wells too closely spaced

mous production has been obtained from several pools in the Los Angeles Basin, which in proportion to its area must be be classed as one of the most productive districts in the world Competition for the oil caused too close drilling and resulted in production so great that markets were unable to absorb the output

Oil interests have finally become convinced of the truth long agitated by economists and geologists, that unrestricted drill-

ing is uneconomical and that the rapid reduction of gas pressure which it entails lessens the amount of oil which can ultimately be obtained from the area In recognition of this, California has a state conservation law. the intent of which is to prevent the waste of natural gas and thereby not only conserve it for industrial use, but, through maintained gas pressure, increase the amount of petroleum which may ultimately be recovered from the producing sands of the area. Such legislation is distinctly forward-looking and reflects the sane view that wanton waste in utilizing natural resources is economically unsound, and that, therefore, the immediate profits of a few must be sacrificed for the ultimate advantage of the many.

High production of petroleum in California seems assured for a number of years. The reserves are great and there is every possibility that further discoveries of producing areas will be be made. If exploitation is kept within bounds and wells are not allowed to run wild, the outlook is good for long-time, steady production. On the other hand, wherever wells are found capable of such large flows as characterize those of parts of California, the dangers of over-production, inefficient exploitation from a scientific point of view, and consequent rapid depletion are great.

Transportation and storage.—Taken as a whole, the petrolleum industry involves mining, transportation, refining, and marketing Each of these phases demands specially designed machinery and methods of operation, the marketing aspect requires not only special equipment, but also specially organized banking facilities and sales forces Companies which carry out all of these processes in their normal business operations are referred to as integrated units of the industry.

Tank cars.—The transportation of petroleum and its products involves the use of three principal methods of shipment; namely, tank cars, pipe lines, and tank steamers. The first to be developed was the tank car, a method of shipment which is still an indispensable phase of petroleum transport In some places tank cars are used to haul crude from wells to refineries, but their more general use is for the distribution of gasoline

from refineries to local markets. During the past two decades the railway tank car has been supplemented by tank trucks for use on the public highways, a development which has caused a marked decrease in railroad shipments. In one form or the other, however, tank cars and tank trucks carrying petroleum products reach nearly every hamlet in the United States.

When production of petroleum in large quantities began, the producers were immediately confronted with the problem of transporting the crude. Petroleum was a new type of commodity, and therefore the railroads were not equipped for the efficient handling of liquid freight. At first haulage was in barrels, a method that proved inadequate from the outset. This led to mounting tanks on railroad trucks, and thus initiated tank car shipment But even this proved unsatisfactory almost from the beginning. The flush production of some of the pools so greatly exceeded even the most hopeful expectations that tank cars with which to handle it were not available In short, the freight car type of transportation for crude oil was not flexible enough for the oil industry, a fact which became obvious within a few years after the discovery well at Titusville had been brought into production.

Pipe lines—Transportation of crude oil through pipe lines was an outgrowth of the method used by the water systems which had already been put into successful operation. This method of moving oil was first used in Pennsylvania about 1865, since which time it has grown to such magnitude that many sections of the United States are served by a veritable network of pipe lines. Pipe-line transportation is the most efficient and the least costly form of overland freight haulage that has yet been devised. The term *pipe line* now implies a complete transportation system, including trunk lines, gathering lines, initial and terminal storage systems, commercial lines, and power plants. The total investment in pipe lines for handling crude petroleum in the United States is approximately $1,000,000,000

Steel pipes of 8 to 12 inch diameters are used for most of the trunk lines, while those of smaller diameters are used for the gathering lines and for some of the main lines. The oil is trans-

ported by means of pumping stations which serve as boosters or pushers to force the petroleum from one station to the next These power pumping stations are spaced according to the density of the oil, topography, and climatic conditions, their distances apart varying from 12 miles to over 50 miles The cost per mile of constructing pipe lines varies from \$20,000 to \$25,000, and pumping stations cost from \$100,000 to \$250,000 each. The daily capacity of an 8-inch pipe, oil 38° Baumé, pressure 800 pounds per square inch, is about 21,000 barrels; larger and smaller diameters of course have capacities accordingly.

The significance of pipe-line transportation of crude oil can hardly he overstated because of its cheapness and its flexibility of operation. The pipe-line movement of crude oil in recent years has reached the astonishing total of nearly 1,000,000,000 barrels per year. Until recently, petroleum pipe lines were used for transportation of crude oil only But with enormously increased demands for gasoline in cities located far from the oil fields, and with intense competition in marketing oil products, the industry was compelled to seek the lowest possible cost methods for distribution of gasoline Pipe-line transportation was the answer. The first important shift in this direction was the conversion of a large pipe line from western Pennsylvania to the Atlantic seaboard Formerly it carried crude from the oil fields of the west to the refineries in the east; now it carries gasoline from the east to the markets west of the Alleghenies Large pipe lines have recently been built from the refineries in the Mid-Continent Province for the purpose of carrying gasoline to the northern markets, a highly significant development of the past few years

Recent years have witnessed also an enormous extension of pipe lines for the distribution of natural gas. Main lines now connect the gas fields of Louisiana, Texas, and Oklahoma with Chicago and Washington, and it is expected that soon every great city east of the Rockies will have natural gas available. Some of the main lines are of huge diameter, from 18 to 22 inches To lay these lines over hill and dale, across large riv-

ers, and to construct them leakproof is a job of the first magnitude. But problems of pipe line manufacture and construction have been so successfully met that this form of transportation has expanded with phenomenal rapidity.

Summing up all three divisions of the pipe line industry, the transportation of petroleum, gasoline, and natural gas, we have a total of about 236,000 miles of pipe line now carrying these commodities in the United States. The total investment involved is estimated to exceed $2,500,000,000 This amazing development has taken place in a comparatively short time.

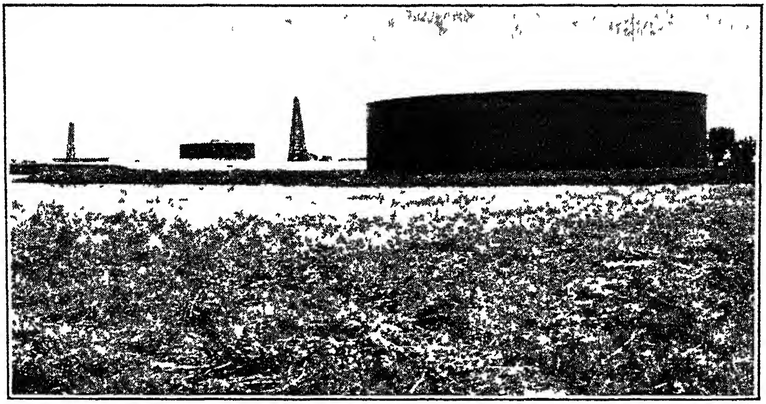


Photo by N A B

Fig. 116.—Tank farm and oil wells near Eldorado, Kansas Note the walls thrown up around the tanks to prevent spreading of the oil in case of fire.

Tank farms.—Oil is produced from wells and run through pipes into receptacles known as *producers' tanks.* These tanks may be large or small, varying with the type of production. Where strong wells occur, the producers' tanks are large; where small wells prevail, the tanks may hold not more than 200 to 500 barrels. From these the oil is transferred by gravity or by pumping into the working tanks which belong to the pipe line systems, and which vary in capacity from 5,000 to 90,000 barrels each. Fifty-five thousand barrel tanks are quite common. Their dimensions are usually about 120 feet in diameter and 30 feet high

Tank farms are aggregates of storage tanks built in connec-

tion with the large refining and shipping centers. They consist of tanks into which the crude is received from field production, and serve as the supply for refinery operation They are large establishments, some of them providing storage for more than 10,000,000 barrels of petroleum. Crude thus stored is a reserve which enables refineries to operate in response to market demands regardless of ordinary fluctuations in the production or shipment from particular fields In some years the amount of crude oil in storage is larger by far than is justified by any possible needs of the oil industry. Aside from carrying a sufficient

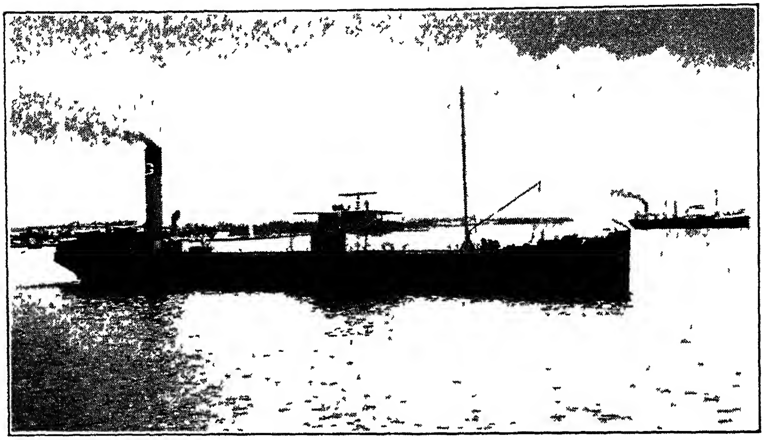


Photo by N A B

Fig. 117.—Tankers in the Gulf of Maracaibo, Venezuela. Note the bridge in the center and the smokestack and engine room in the rear.

amount of oil above ground to assure steady operation of refineries there is no gain, because underground storage is the best and cheapest method Substantial increase in total tank storage capacity in the United States therefore seems improbable as long as petroleum is the principal liquid fuel involved.

Oil tankers.—When shipment of crude oil by water became necessary, a new type of vessel, the *tanker,* was devised to meet the demand It is, as its name implies, a steel ship divided into compartments and equipped with pumping apparatus whereby loading and unloading may be quickly accomplished. With the extensive international trade in petroleum which has de-

veloped during the past quarter of a century, tanker tonnage has had almost phenomenal growth. It is estimated that more than 10 per cent of the total merchant shipping of the world is now of this type.

The average size tanker plying between Caribbean ports and New York City has a capacity of approximately 10,000 tons, or over 60,000 barrels, of crude In general, smaller boats ply between Mexico and the Gulf ports of the United States, while much larger ones operate in the trans-Atlantic service. A notable example of high development of small, shallow draft tankers is found in the Lake Maracaibo basin of Venezuela The

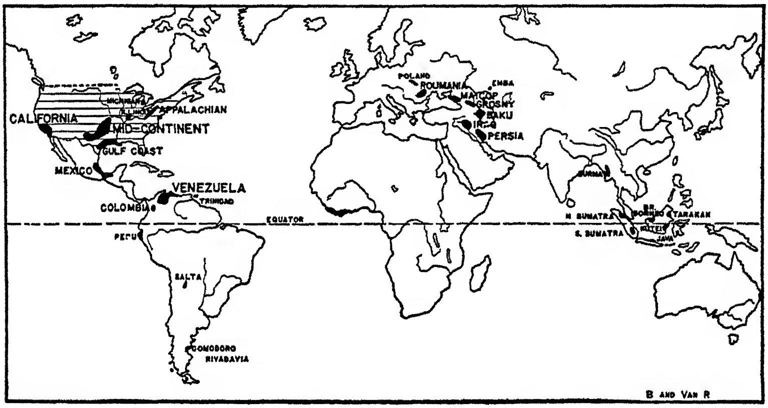


Fig. 118.—Principal oil producing regions of the world.

entrance to Lake Maracaibo is shallow, not more than twelve feet during high tide, and therefore permits only light draft tankers to carry the oil from the lake to the deep water ports of the islands of the Dutch West Indies—Curaçao and Aruba—which lie relatively close to the Venezuelan coast. There refineries have been built from which the products are exported to the various parts of the world in large vessels especially constructed to handle that type of freight. Some of the crude is transferred to ocean tankers at the deep water harbors of these islands, and exported to refineries in the United States and Europe.

Petroleum in foreign countries.—Since 1859 the United

States has produced approximately 65 per cent of the total world supply of petroleum, and at the present time about 60 per cent is being produced in this country The foreign countries which rank high in importance are Russia, Venezuela, Mexico, Iran (until recently known as Persia), Iraq, and Rumania

The probable reserves of oil and gas of the various continents are far from equal On the basis of present evidence, North America must be rated highest and the United States given the most favorable position. The northeastern half of Canada consists of a great block of ancient crystalline rocks which give no hope of oil. The vast plains which begin in Canada, extending through the United States and terminating in eastern Mexico, comprise the most promising and at the same time the most productive large area in the world.

South America.—In the South American continent the best undeveloped prospects appear to lie in the upper valleys of the Orinoco and the Amazon, and in the plains east of the Andes in Bolivia and Argentina Most of eastern Brazil is a crystalline upland, where the existence of oil is not believed possible The vast stretches of the Andes are so severely distorted that oil can occur only in scattered basins.

Commercial exploitation has thus far proved successful in Venezuela, Colombia, Ecuador, Peru, and Argentina The first named has ranked second or third in world production in recent years, with the Maracaibo basin as the chief center of operations Commercial production has now been reached also in the Orinoco basin, and there seems to be a strong probability that large unmined reserves exist Venezuela may therefore be expected to retain her position as one of the leading petroleum countries of the world

Peru first appeared in the records as an oil producer in 1896, but did not reach the million-barrel per year figure until 1909. Since 1926 the annual production has ranged between 10 and 14 million barrels. The fields are in the northwestern part of the country, along the Pacific coast and south of the Gulf of Guayaquil. Production has also been developed in southwestern Ecuador, but there the fields so far discovered are not extensive

The output first exceeded a million barrels in 1928; since then it has remained between one and two million barrels per year.

In Colombia the principal producing fields are on the low flanks of the Andes, about 425 miles inland along the east valley side of the Magdalena River. Since 1929 the output has been around 20,000,000 barrels per year, but the possible production appears to be much greater than that actually attained The field is connected with ocean shipping facilities by a pipe line more than 400 miles long.

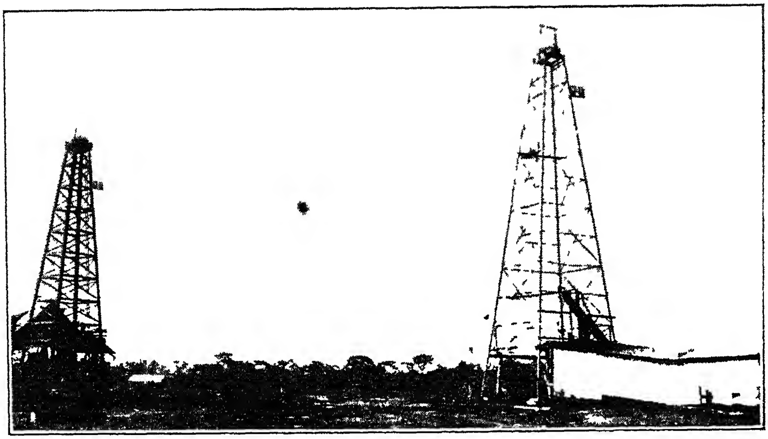


Photo by N A B

FIG 119.—**La Rosa, Maracaibo Basin, Venezuela. Well at left (wooden derrick) yielded 1,800,000 barrels and the new well at right (steel derrick) 1,400,000 barrels of petroleum in less than three years. Wells still active producers.**

Argentina has had slow but steady growth in petroleum output since 1913. Lately, the annual production has exceeded 14,000,000 barrels, with prospects of further increase in the coming years The principal centers of output are the Comodoro Rivadavia field, about 900 miles south of Buenos Aires, and the more newly discovered fields east of the Andes in northern Argentina The latter appears to be a continuation of similar conditions existing in Bolivia, where oil seeps have long been known and where active prospecting for production is in progress.

Europe.—The rocks of southern and western Europe are so broken and disturbed that there cannot be any large areas of oil lands, but there is a reasonable probability that small fields may be developed in addition to those now known in Alsace, Hanover, Galicia, Rumania, and northern Italy. In eastern Europe, beneath the great plains of Russia, are beds similar to those which have yielded much oil in the interior United States and on the flanks of the Caucasus Therefore, these Russian plains, at present of no importance in oil production, appear to have reasonable potentialities which may become known through further exploration.

Russia and Rumania.—Russia and Rumania lead all other European countries in output by a wide margin. Rumania has been producing petroleum for more than 75 years, and during the last few years the output has increased substantially, from 39,279,000 barrels in 1929 to nearly 60,000,000 barrels in 1934 Russia became a petroleum producer before 1870, and has consistently been one of the leading nations, usually ranking second or third; from 1898 to 1901 she took first place, even surpassing the United States The principal fields are in the southeast, the Baku field on the Apsheron peninsula and the Grozny field along the north flank of the Caucasus Mountains being especially important The total annual production of the country has increased sharply in late years, having practically doubled since 1928 In 1934 it was unofficially estimated at over 169,000,000 barrels It appears probable that Russia, for years to come, will retain second place in the oil industry.

Asia.—So far as the occurrence of petroleum is concerned, the extensive continent of Asia is largely an unkown area, but the evidence thus far found gives little indication of vast reserves of oil. The most promising areas appear to be in western Siberia, in the plains and foothill belt east of the Caspian Sea, in southwestern Persia and the adjacent territory now included in Iraq, and in the coastal lands and islands of the southeast. In general, the oil possibilities of Asia must be rated low in comparison with the size of the continent, and yet Persia and

Iraq give promise of exceptionally large output when developed. Exploratory work thus far completed in those countries has been rewarded with extraordinary success

Persia.—In American statistics, Persia first appeared as an oil producer in 1913, credited with an output of 1,857,000 barrels Since 1920 progress has been rapid, leading to an output of approximately 53,000,000 barrels in 1934 and placing the country fifth among the nations in this respect The producing areas are along the south flank of the Bakhtiari Mountains of western Persia, nearly due north of the head of the Persian Gulf. The crude is transported by pipe line about 150 miles to a large refinery constructed on the island of Abadan, below Basra, on the Shatt El Arab, whence the products are shipped by water routes to the export markets of Asia and Europe English capital is dominant in the Persian oil industry Inasmuch as active exploratory and drilling campaigns are in progress, the future promises still greater production.

Iraq—The kingdom of Iraq is one of the latest additions to the family of petroleum producing nations The oil fields are located at Kirkuk, in northern Iraq, about 100 miles southeast of ancient Nineveh. Although strong wells were proved several years ago, commercial production was delayed because of lack of transportation facilities. A 1,150-mile pipe line of 12-inch diameter and with a daily capacity of 85,000 barrels was begun in 1932 and completed for active service January 14, 1935. It is a double line from Kirkuk to Haditha on the Euphrates, a distance of 150 miles, from whence it bifurcates, one line crossing Syria to Tripoli on the Mediterranean coast, the other crossing Trans-Jordania and Palestine to Haifa It takes crude from Kirkuk about 21 days to reach Tripoli and 25 days to reach Haifa This line will be able to carry 30,000,000 barrels of crude yearly to the Mediterranean ports, and present indications point to Iraq's continued prominence as a petroleum producing country.

Southeastern Asia.—India and the East Indies have long been important in the petroleum industry of the world. India's production dates back to 1894 Increase was slow but

steady until 1915, since which time the output has remained consistently between eight and nine million barrels per year. Sarawak (British Borneo) has come into relative prominence since 1920, the output exceeding 5,000,000 barrels in 1929 but dropping to about 2,000,000 barrels in 1934 English interests are dominant in both India and Sarawak.

Netherland India became an important oil producer in the nineties, and the increase has continued rather consistently

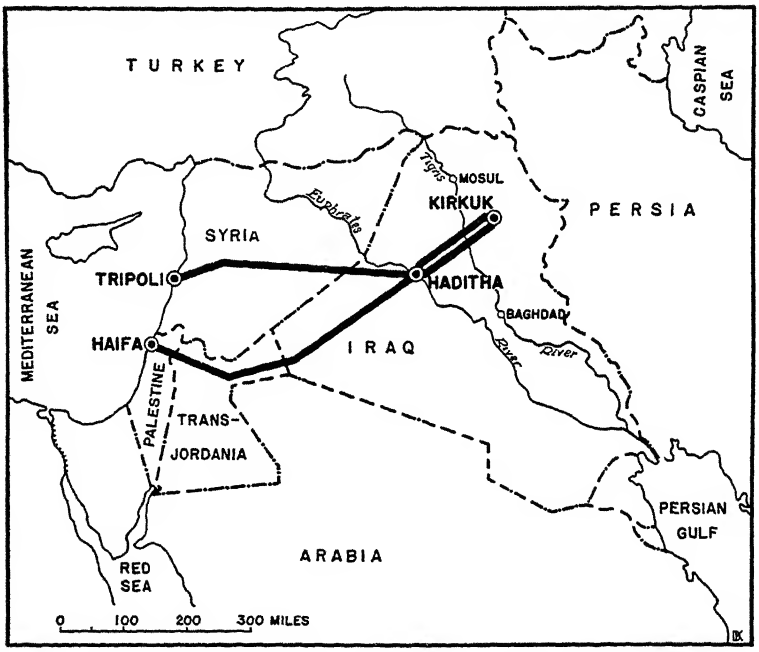


Fig. 120.—Map of pipe lines from the Iraq fields to the Mediterranean.

during the present century The output in 1924 was 20,473,000 barrels, ten years later unofficial estimates placed it at about 43,500,000 barrels The capital interests are chiefly Dutch, but not exclusively so

Eastern Asia—Japan, including the island of Taiwan, has appeared in the list of petroleum producing countries since 1875, but the output was small until after the turn of the century. In spite of energetic exploratory work, the annual pro-

duction remains at a comparatively low figure, only slightly exceeding 2,000,000 barrels. It seems probable that the Japanese petroleum industry will remain stabilized at the present level for some time

Manchukuo, Chosen, and eastern Russia, including coastal islands, include areas which are classified as potential petroleum producers, but actual output to date has been small China has been given high rating in potential areas by some, but the published evidence is not convincing

Africa—Egypt is the only country of Africa wherein important petroleum production has been achieved The first commercial production was reported in 1911, and for some years the prospects for large output were widely heralded These have not been realized however, and the yearly output has not yet reached 2,000,000 barrels. Although wells in some other countries have proved the presence of oil, the results in general have been disappointing from the standpoint of economic return

Africa is not credited with any large oil potentialities Much of the interior of the continent is a crystalline plateau, and therefore the likelihood that oil may be found seems slight Much of the Sahara is unknown territory as to oil possibilities. The small quantities thus far produced in Africa have been obtained from the folded sedimentaries which, in some localities, fringe the margin, and future discoveries will probably be limited to the same types of areas.

Australia.—Australia likewise has areas of crystalline rocks too extensive to warrant hope of any large percentage of potential oil land Local pools may be found, but as a continent it is not likely to rank high.

On the basis of present knowledge, the great oil reserves of the world are in North and South America, in Russia, and in southwestern Asia including particularly the Persian and Iraq districts

Capital interests.—The capital interests of the United States, England, the Netherlands, and Russia control the major portion of the world's future oil supply insofar as this can now

be estimated. The economic and political control of the world's reserves is not easy to determine with exactness, but it seems safe to assert that the oil industry is pretty largely in the hands of British and American capital. English capital, in view of the absence of oil within the British Isles, became impressed early with the profits which might result through the development of foreign fields For this reason the British were most

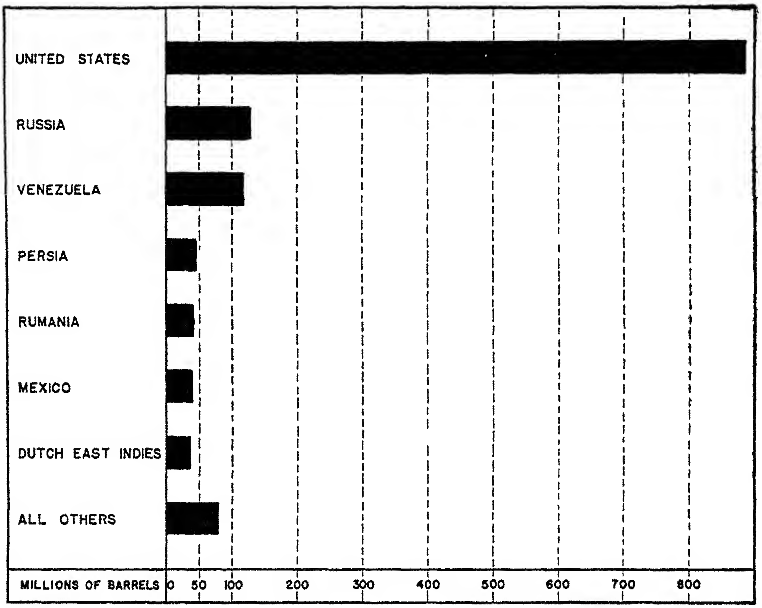


FIG. 121.—Graph showing oil output of the principal producing countries. Average 1928-1932. (Source of data: *The Mineral Industry*, edited by G. A Roush)

energetic in obtaining concessions and exploratory rights in potential areas all over the world, while American genius and capital, fully occupied with the rapidly expanding domestic industry, gave little attention to foreign fields. Therefore, on the whole, the British interests are more completely integrated as to production, refining, and marketing on a world basis than are the American

When coal was the bunker fuel of the day, Britain developed coaling stations all over the world in order to give fuel service to ships in merchant commerce. With the shift to petroleum, she was in position to equip similar stations for bunkering with petroleum and its products, a situation of which she took full advantage. The net result is that, although American capital is in the lead in present production, the position of the British is secure for the future Under these conditions, commercial rivalry might become such as to produce serious economic consequences but, with the growing spirit of coöperation in industry, it seems highly probable that no disastrous economic antagonism will be allowed to develop. Through friendly coöperation there is ample opportunity for all interests concerned to achieve the economic success conducive to their common prosperity.

Summary of the petroleum outlook.—A feature of industrial development which promises tremendous consequences is the expanding use of liquid fuels. Through new technological processes it is possible to convert practically all the crude petroleum into valuable products and by-products This means increased efficiency to a degree few believed possible some years ago. Furthermore, processes of liquefying coal give promise of commercial success; and if this should materialize into common practice, the effects upon transportation and industry would be revolutionary Haulage of liquid fuels can best be accomplished by pipe lines Until recently only crude oils were so transported, but now pipe lines are used for transporting also the light derivatives, especially gasoline. Should liquefaction of coal become commercially and industrially successful, its products also would be transported by pipe lines, and the railroads would be deprived of the greatest single commodity now being carried. The effects of such change would extend to practically every realm of industry, affecting manufacture of rolling stock, the steel output, and a host of industries contingent upon these key commodities.

The capital interests of a few countries so completely domi-

nate the oil industry of the world that by agreement they can readily determine what trade policies shall prevail Supplementing these powerful capitalistic groups are hosts of minor ones whose local interests are important but whose influence on the whole is slight Perhaps no other great industry, whose influence permeates all the corners of the world, is dominated by so few countries and so few men

Within the United States the petroleum industry is widely diversified A few great corporations are of course in positions of accepted power and leadership, but the number of small independents is legion. In the fierce competitive struggle which has raged for some years and which still shows little sign of abating, uneconomic production and marketing practices have been carried on Too many wells have been drilled; too many filling stations have been built These and similar practices have impoverished an industry which should be prosperous In time it seems that the inevitable toll must be paid Uneconomic production and trade practices will be forced out, many small companies will disappear, and greater prosperity will be attained under the leadership of fewer companies more intelligently managed Within the nation, as among the nations of the world, coöperation toward the goal of elimination of waste effort as well as conservation of natural resources is the sane road of social progress

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CHAPTER XII

The Geographic Distribution of Water Power Resources

THE clouds which gracefully drift across the sky often tend to remind us of sailboats carried to their destinations by a strong and steady wind. Ordinarily we admire the clouds because of their effortless movement or their everchanging forms, but we should also admire them as one of the most essential and efficient transportation agencies known to man. The clouds contain moisture condensed out of the invisible water vapor which is nearly always present in the air. As clouds or as vapor the moisture is transported often thousands of miles, to be unloaded as rain, snow, or hail, wherever conditions are favorable.

We do not know for certain how much precipitation falls over the oceans, but the sum total of the moisture falling on the land in the course of a year amounts to approximately 30 inches, representing 27,000 cubic miles of water, weighing about 120,000,000,000,000 tons Much of this enormous quantity of water is carried yearly in the form of clouds over land and sea. The sun furnishes the energy necessary to evaporate this mass of water, thus lifting it into the air. As invisible water vapor or as visible clouds the moisture is then propelled by the winds to various points of destination. Of the rain which falls on the land much evaporates or soaks into the ground, but probably 35 per cent eventually finds its way as run-off and spring water to brooks, creeks, and rivers. According to this estimate 9,450 cubic miles of river water reach the sea yearly Since the average altitude of the land is about 2,500 feet, one can readily realize that the amount of energy contained in the flowing waters of the continents is enormous

Streams as early sources of power.—Streams have long been utilized as sources of power, because man early learned to put a simple paddle wheel into the water and thus make it turn and do useful work for him. For such primitive methods of water power development only small streams with steady flow and fairly swift currents could be utilized. Even then only small amounts of power could be developed. In order to render the flow more uniform and dependable it was often necessary to construct reservoirs, but these could not be large since man lacked the means of constructing strong non-leaking

Fig 122.—Old water mill in Massachusetts, restored by Henry Ford.

dams. No wonder that with the advent of the steam engine man turned to coal as a larger and more convenient source of energy.

Three major inventions have provided the magic whereby water power has been changed from a Cinderella to a princess. (i) The invention of the turbine has made it possible not only to use much larger amounts of water, but also to increase greatly the height from which the water may be made to fall. The invention of the dynamo (ii) has made it possible to convert the energy of the falling water into electricity, and finally, the invention of Portland cement (iii) has enabled man to construct dams

hundreds of feet high and thousands of feet long, by means of which even the largest rivers can safely be impounded

At present hydro-electric power is of major importance in most industrial countries. This status has been attained within the past fifty years, an achievement which has resulted from a recent evolution in the utilization of a resource that had been exploited in a small way for many centuries

The amount of energy which flowing water contains depends

Courtesy, Schweizerischer Wasserwirtschaftsverband

Fig. 123.—Storage reservoir high in the Alps (6,500′) serving as regulator for mountain type of power development. Fully plant, southwest Switzerland. Fall of water 5,400 feet.

upon both the quantity of water and the velocity of the current. The latter, in turn, depends upon the gradient of the stream The Mississippi in its lower course has a gentle gradient, its waters are sluggish and the river does not offer such attractive possibilities for power development as does, for example, the rushing, turbulent Columbia, with its relatively steep gradient

Waterfalls illustrate the maximum velocity of flowage and usually make the best water power sites In his hydro-electric

plants man really imitates Nature's waterfalls Through large tubes, capable of withstanding tremendous pressures, the water is made to plunge from great heights into the turbines Where a natural fall is available all that needs to be done is to divert part of the river above the fall to these tubes, commonly called *penstocks*. These lead the water downward into the hydro-electric plant, which is built in the gorge or narrow valley near the foot of the fall Such is the case, for example, at Niagara Falls, where the power companies have constructed long intake canals and rock tunnels to carry the water to the penstocks

It is greatly to be regretted that this diversion of water sometimes tends to impair the beauty of the falls. In most cases, as for example at Niagara, a happy medium can be struck whereby both the requirements for power and the demands for the preservation of natural beauty can be satisfied.

In mountain areas of the Alpine type the streams derive a fairly steady flow from the permanent snow and icefields of the summit regions. These snowfields have often been referred to figuratively as "white coal"—a name now quite generally used for all hydro-electric energy. Most mountain streams are relatively small, but their gradients are so steep that without much difficulty man can construct artificial falls and, by utilizing the great drop, he can make up for the smaller amount of water. This is done by leading part or all of the water nearly horizontally along one of the valley sides through conduits or open canals until the desired height above the valley bottom is reached. From this point the water is allowed to plunge through one or more penstocks to the power plant at the foot of the slope (Fig. 124). In the Alps the water often thus plunges from four to five thousand feet before reaching the turbines at the base. This type of water power development is typical of many high mountain areas.

In some favorable cases where a large stream flows through a deep and narrow canyon man can create a veritable artificial Niagara This, for example, is done in the canyon of the Colorado River by the construction of Boulder Dam, 730 feet high and reaching from canyon wall to canyon wall. Thus, not only

a great height of fall is created by raising the water to near the level of the dam, but also large quantities of water are made available to feed numerous penstocks In their gigantic potentialities, sites such as that of Boulder Dam vie with the large natural falls, such as the Niagara or Victoria Falls.

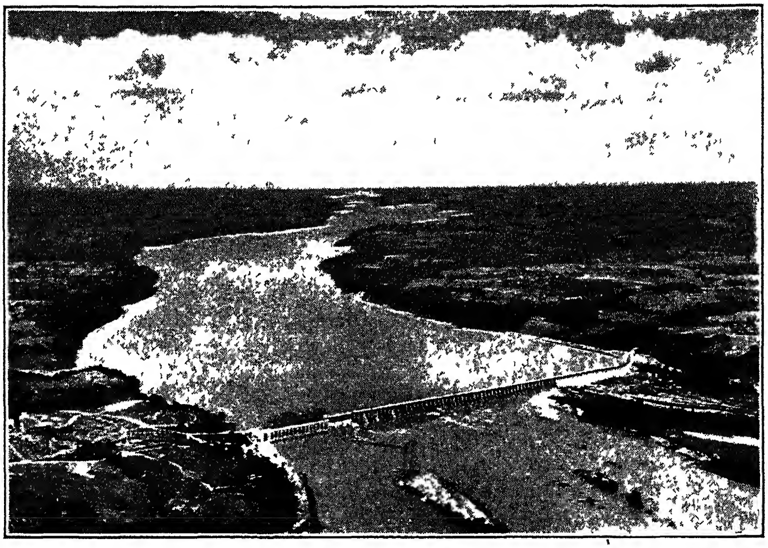
Courtesy, Schweizerischer Wasserwirtschaftsverband

Fig. 124.—Water power development in high mountains. Barberine plant in southern Switzerland. Only the lower part of the penstock and the power plant in the valley are shown. The water falls 2,400 feet.

In the lowlands streams tend to be sluggish and broad, but they often carry large amounts of water. By constructing dams across the rivers man cannot raise the stream level to great heights, but the smaller drop is compensated by the large volume of water available Examples of this type are the Keokuk

dam across the Mississippi and the Conowingo dam across the Susquehanna This type of hydro-electric development is, in most instances, costly per unit of power produced, and therefore the number of developed sites in this category is relatively small.

Characteristics of streams favorable to water power development.—From the above it is evident that, given a market, the conditions most favorable for modern hydro-electric devel-



Courtesy, Philadelphia Electric Company

Fig. 125 —Water power development of a lowland stream. Conowingo Dam and plant on the Susquehanna River, Maryland. Installed horsepower, 378,000; length of dam, 4,648 feet, developed head, 89 feet.

opment are a large flow of water coupled with a great fall height, preferably provided by nature Where such ideal conditions do not prevail, a relatively small flow of water should be accompanied by a steep gradient, and a gentle gradient by a large quantity of available water.

For practical purposes a hydro-electric plant must be able to furnish approximately the same amount of current the year through It is here that water power development encounters one of its chief problems, since most rivers are subject

to pronounced seasonal fluctuations in volume The Missouri, for example, has recorded a difference of nearly 20 feet (1881), at Omaha between high and low stages in a single year, and of course it is well known that the high stage of a river is marked by a sharp increase in velocity as well, and thus the difference in power potential is even greater than the relative stages of water level would first suggest.

There is an intimate relationship between river regime and the climate, topography, and vegetation cover of an area In a region of oceanic climate the regime will show less fluctuation than in a region with a pronounced wet and dry season, as for example in the tropical savannas or the dry interiors of the continents. Rivers which derive most of their water from mountain glaciers generally are more dependable than those which obtain their water from precipitation in a lowland area Rivers which flow through well forested mountain regions have a more uniform volume than those flowing through mountain areas which have been deforested and where the surface litter has been removed by erosion.

Where nature has provided storage basins in the form of lakes we find the most equable type of river regime Well known examples of this type are the Niagara and the St Lawrence rivers, both of which head in large lakes, and both of which are noted for their remarkable constancy of flow The glaciated areas of North America and Europe, where numerous small lakes abound, are characterized by streams whose volumes are relatively uniform and thus lend themselves to power utilization. There small dams can be constructed at low cost and with slight hazards; power at minimum cost is thus obtained Where lakes are absent it is often necessary, and always desirable, to construct storage reservoirs to equalize stream volume and thus increase the potential available power during the low water period.

Principal water power regions of the world.—To the regions most favorable for water power development belong those parts of the Canadian and Scandinavian shields which have been intensively glaciated There large lakes abound.

is high, plateau-like, and practically all the rivers have falls or rapids near the coasts. In South America the greatest power possibilities occur along the fall line, which extends around the Brazilian plateaus, and in the well watered portions of the Andes.

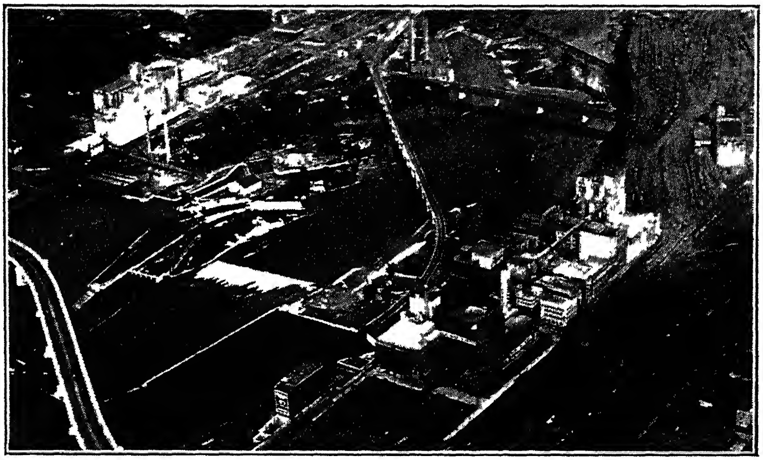
The large potential water powers of the streams of Africa, South America, and Asia have hardly been touched as yet, because they are found either in regions where population is sparse or where modern industrialism has made but little advance. Japan alone has made great strides in hydro-electric development The continent of Australia is too arid to be able to produce much water power. It seems certain, therefore, that North America and Europe will hold the center of the stage for a long time to come as far as hydro-electric development is concerned.

Development of water power in the United States.—During Colonial times water power played an important role in America, especially in New England, where, as a result of the glaciation, falls and rapids were numerous, and where the volume of the rivers was small and quite uniform. Each town had its own grist and saw mills driven by water power, and even the bellows of the smithy were often activated by falling water. In the South, physical conditions were unfavorable for small-scale development: the rivers were larger, and their flow was subject to greater fluctuations As a result of these circumstances water power in that section of the country never attained the importance in Colonial life which it did farther to the North In New England the falls and rapids were soon called upon to furnish motive power for the operation of factories (still called "mills"!) and thus made possible the early industrialization of that part of the New World

With the introduction of coal, water power for a time lost much of its early importance in the development of American industry. Since 1900, however, the modern water power industry, based upon the generation of electricity, has made rapid strides in most parts of the United States In 1890 the amount of water power produced was approximately 1,280,000 horse

power, used mostly without being transformed into electricity In 1930 the total amount of water power was 14,885,000 horse power, used almost entirely in the form of electrical energy.

Water power regions in the United States.—The northern and northeastern recently glaciated sections of the United States are favored by numerous streams and lakes, generous precipitation, and nearness to population centers. Water power is developed more extensively there than in any other part of the United States. Niagara Falls ranks supreme, but the swiftly flowing St. Lawrence between Lake Ontario and Montreal



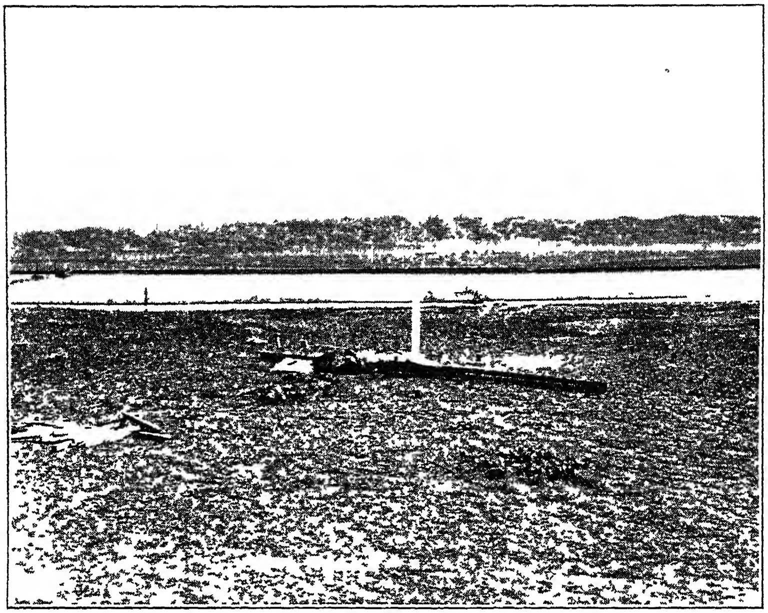
Courtesy, Minneapolis Civic and Commerce Association *Photograph by I F Westover*

Fig. 127.—Industrial development around a water power site, the former St. Anthony Falls in the Mississippi at Minneapolis. Flour mills on either side of the river.

also offers many favorable sites for large scale hydro-electric development. Another well-known site is that of the St. Anthony falls at Minneapolis.

The Appalachians form another water power region, especially in the south, where the mountains reach elevations of more than 6,000 feet. There rainfall is abundant, averaging probably from 60 to 80 inches From the mountain slopes numerous streams of large volume and steep gradients descend to the lower adjacent lands of the Piedmont region, where population is relatively dense and where need for power is great Still far-

ther east, beyond the mountains proper, the streams pass abruptly from the hard rocks of the Piedmont to the soft rocks of the Atlantic Coastal Plain Near this line of contact, the so-called "fall line zone," we find some of the best water power sites of the region In recent years extensive cotton industries have developed there, attracted by water power, cheap labor, and proximity to raw material On the west side of the mountains the Tennessee River project, of which the Muscle Shoals unit is the best known, presents great possibilities.



Courtesy, Corps of Engineers, War Department, U S A

Fig. 128.—Site of the Fort Peck Dam, in course of construction. The dam will extend across the valley to mark shown on skyline in center of picture.

In the large central plains between the Appalachians and the Rocky Mountains, gradients are gentle and river valleys are wide. In the western section the annual rainfall is low and stream volumes are small Furthermore, since the valleys are generally quite wide and the valley sides relatively low and gently sloping, the natural conditions are, for the most part, unfavorable for hydro-electric development on a large scale. In

some places, however, streams flow over rock beds, channels are quite narrow, reservoir sites are available, and market demands for power are such as to justify development A few such sites have been developed and power plants are in operation, while in other instances they are still to be ranked as important potentialities for the future Among the developed power projects the Mississippi River at Keokuk ranks foremost in the Central Plains region The falls of the Missouri at Great Falls are partly utilized by a large copper refinery Further utilization of the Missouri by what is known as the Fort Peck Reservoir project will add another important development to the few thus far in operation

Potential water power resources are greatest in the northwestern part of the United States. The west slopes of the high Cascades, facing the moisture-laden westerlies from the Pacific, are noted for their heavy rains and winter snows, the latter alone exceeding 30 feet in some years Of the total amount of potential water power in the United States, 31 per cent is in Washington and Oregon The absence of extensive coal beds and of oil deposits in that section of the country enhances the value of water power resources. In California the western slopes of the Sierra Nevada catch the rain-bearing winds from the Pacific. Although the tributaries of the Sacramento and San Joaquin are relatively small, their swift descent gives rise to comparatively great power potentials. As a result of the demands arising from a denser population, the water power resources of California are more fully utilized than are those of the other Pacific states

The Colorado River flows through one of the most arid sections of the country, but melting snows in the headwater areas of the mountains and plateaus furnish abundant water. In most of the region power development is incidental to the conservation of water for irrigation The Coolidge and Roosevelt Dams, on two of the southern tributaries of the Colorado, already serve this dual purpose The Boulder Dam project on the Colorado River ranks as one of the largest irrigation and power projects in the world. It is designed to equalize the flow of the

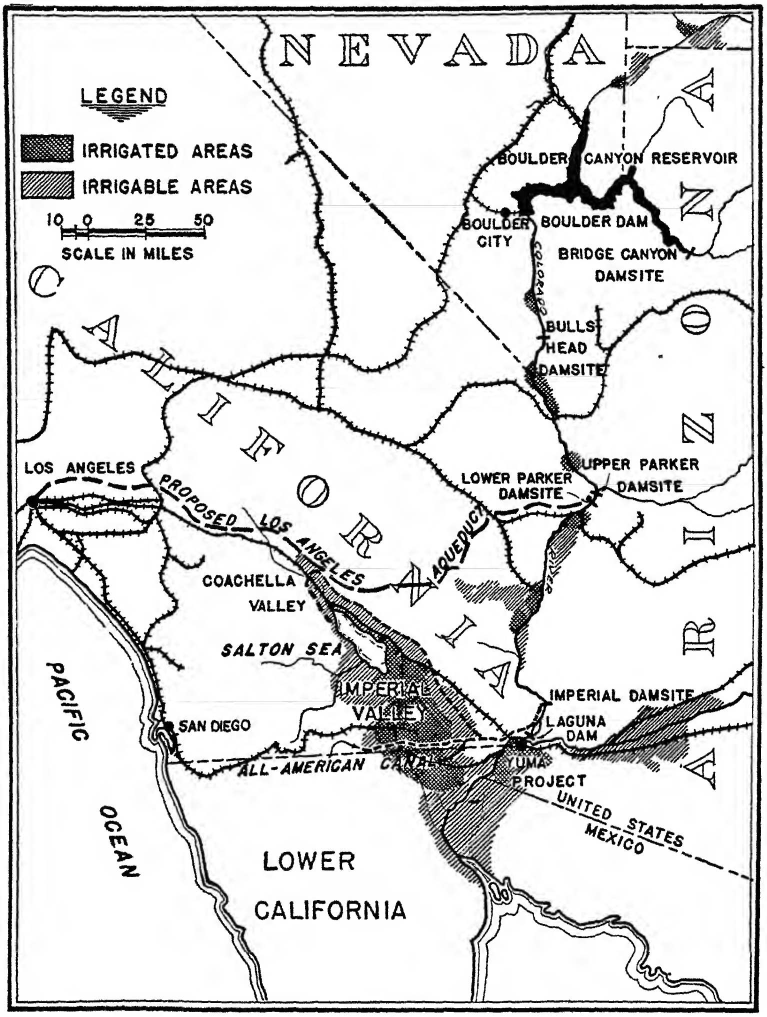
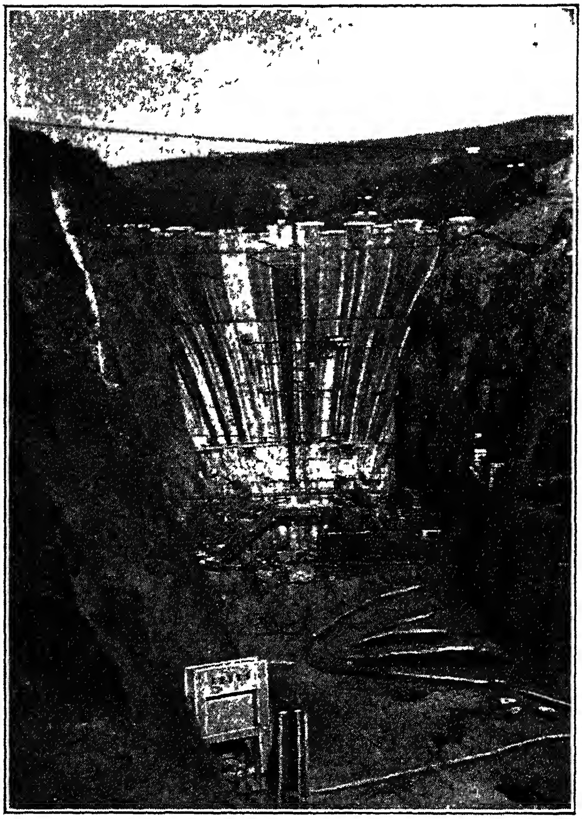


Fig. 129.—The Colorado River Basin below Boulder Dam (After a map by C L Raum, Bureau of Reclamation, Washington, D C)

lower Colorado in order to prevent loss of water during times of flood, to furnish water for irrigation throughout the year, to increase the area of irrigable land, and to produce cheap power for industrial purposes.

Water power development in Europe.—Italy, France, Switzerland, Germany, Norway, and Sweden produce 80 per

cent of the hydro-electric power developed in Europe. The combined production of these countries is only slightly less than that of the United States



Courtesy, U S Bureau of Reclamation

Fig. 130.—Boulder Dam under construction. Note depth and narrowness of canyon. Looking upstream.

In Italy the absence of coal resources has served as an incentive to the development of water power. Much of the country is mountainous and receives considerable precipitation. This is especially true of the Alps and the northern Apennines. The principal power sites in Italy are found in the mountains which surround the densely populated and industrial Po Basin.

Since the war France has more than doubled its production

of hydro-electric energy. The streams which head in the Alps, the Pyrenees and the Central Plateau provide most of this power A relatively high degree of development has been reached because of the industrial needs of the country and the absence of important coal deposits in central and southern France. Furthermore, the rather exposed location of the principal coal fields in the northern frontier serves to intensify the desire for water power development as part of the program of national defense

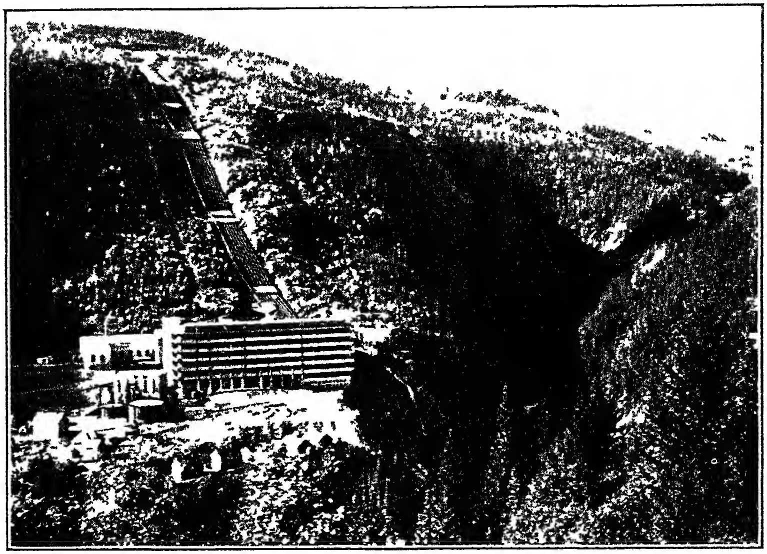
Switzerland is a highly industrialized country which depends almost entirely upon water power At present 80 per cent of the railway trackage is electrified. The potential water power resources of Norway exceed those of any other European country. They are estimated to be about 10,000,000 horsepower, of which less than 2,000,000 have been developed to date. Sweden also has abundant water power resources

As a continent, Europe is rather fortunate in her distribution of power resources The countries which have little or no coal —as Norway, Sweden, Switzerland, and Italy—are rich in water power, while the countries weak in water power resources —as England, Poland, and Germany—are rich in coal France and Russia are fortunate in having both coal and water power resources on a large scale

Water power and industry.—Water power developments not only provide neighboring communities with light and power for domestic purposes, but they usually sell a large percentage of their current to industry. This is facilitated by the fact that, with the aid of high tension lines, electricity can be distributed over large areas In recent years the distance at which it is profitable to transmit electricity has been increasing steadily, and the networks of power lines are ever expanding. Nevertheless, there are a number of industries which tend to congregate around power sites because of their large demands for cheap power Among these should be mentioned the so-called electro-chemical industries, as for example the manufacture of nitrates and calcium carbide, and the electro-metal-

lurgical industries, as for example, the manufacture of aluminum and special alloys

Water power and conservation.—Water power resources, in contrast to mineral deposits, are not wasting assets. As long as rain and snow continue to fall, running water will be a potential source of energy. The realization that this energy can lessen man's burden of work has made us more and more desirous that this power be utilized. The fact that no fuel need be purchased by hydro-electric plants has led many people to



Courtesy, Norwegian Government Railways, New York City *Photograph by Wilse*

Fig. 131.—Penstocks and power plant in Norway, Rjukan I. Capacity 122,000 H.P. The current is used primarily for the manufacture of artificial nitrate and ammonia.

believe that electricity can be produced and distributed by such plants almost free of charge, or at least much more cheaply than by coal-burning plants. This impression is often erroneous, owing to the fact that the public fails to take into consideration the huge expenditures necessary for the installation of great water power plants, the costs of maintenance, the interest charges, and the relatively rapid obsolescence of plant and equipment. The cost of steam-generated power has been re-

duced materially in recent years, and these costs may be reduced still more. In water power development, however, the costs are likely to rise. As the more favorable sites are taken first, development must be extended to less favorable sites. This, of course, will tend toward greater expenditures for installation, and therefore toward higher fixed charges. In the United States, particularly, the great reserves of coal and the low cost of mining give promise of continued cheapness of steam power, and this factor may delay for a long time the development of many of the less favorably located water power sites.

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CHAPTER XIII

The Geographic Distribution of the Iron and Steel Industries

IN AN earlier chapter attention was called to the fact that from the standpoint of economic geography the mineral resources may be classified into three broad groups: (1) those which constitute the major components of the common rocks, (2) those which are used without any important manufacturing processes, and (3) those which serve as the sources of fundamental raw materials for industry. Among the various minerals which constitute the third group, the ores of iron, copper, lead, zinc, tin, and aluminum are of foremost importance Nations rich both in mineral fuels and in the ores from which the leading metals are derived have the basic resources with which to achieve industrial greatness. While the metals named above are used in the greatest quantities, other metals are essential to industry because of the particular qualities they impart when used as alloy materials with those of the major group. In this latter class the so-called steel hardening metals are the best known; for example, manganese, nickel, cobalt, chromium, tungsten, and vanadium. Without them, many of the metallic products in common use now would be worthless because the desired qualities, such as cutting edge, elasticity, hardness, or resistance to rust, could not be attained.

While all the metals named are essential to industrial progress, and no one of them outranks all the others in every respect, from the standpoint of quantities used there are significant differences. On such a basis iron is far in the lead and therefore is usually considered the outstanding member of the group.

Kinds of iron ores.—The term *ore* as used in industry refers to a natural mineral resource which has present or potential economic value. There are iron compounds in the rock and the soil of vast areas of the land, but they are not classed as ores because the possibility of extracting iron from them economically is too remote. There are four principal groups of iron compounds which occur in bodies large enough to be worked as iron ores; namely, hematite, limonite, magnetite, and siderite. While these compounds are of widespread occurrence in rocks and soils, in some places they occur in large masses with relatively small percentages of impurities It is from such masses, known as ore-bodies, that most of the world's supply of iron is obtained.

Hematite is the most important industrial iron ore in the United States. When pure it contains nearly 70 per cent of metallic iron, but where mined it is always mixed with some impurities so that the actual percentage of available iron is considerably less Its color is usually reddish or so-called ocher-red, although in some instances it is almost black or even bluish While not the most widespread of the iron oxides, hematite ranks first in industrial importance because of the relatively high grade ore bodies in which it is found and the ease with which it may be mined and smelted

The most common of the iron oxides is *limonite*, one of the oxides wherein water is an essential part of the composition It is widely distributed over the earth and occurs in varying degrees of hardness; its color range is from yellow to dark brown Limonite commonly gives a yellowish or brownish color to the subsoil, but it is known as an ore only where it occurs in bodies large enough for successful mining operations When pure it contains nearly 60 per cent metallic iron, but as mined it is mixed with impurities which reduce the recoverable iron content.

The richest of the common iron ores is *magnetite*. Some varieties act as natural magnets and, therefore, are designated as *lodestones*. The color is darker than that of hematite or limonite, varying from deep dark brown to greenish black. When

pure, magnetite contains 72.4 per cent metallic iron, but in actual mining operation the ore is considered to be high-grade if it yields more than 64 per cent metallic iron.

The three ores thus briefly described, namely, hematite, limonite, and magnetite, constitute the principal sources of primary iron in the world today. All three are essentially chemical combinations of the elements iron and oxygen, in varying ratios. In the earlier period of development of the iron and steel industry much dependence was placed upon a carbonate of iron known as *siderite*, consisting chemically of iron, carbon, and oxygen. When pure, siderite contains about 48 per cent metallic iron, but the actual ore mined is mixed with impurities which materially reduce its iron content, in some cases to less than 40 per cent. Although the percentage of metal is not so high as in the oxide ores, siderite is usually free of undesirable impurities, and hence it is easy to smelt. Siderite was in large measure responsible for the quality of steel products which long ago gave Sweden and England their high reputations in the manufacture of sharp-edged instruments. This reputation still endures and is a valuable business asset to the cutlery industries of those countries.

Distribution of iron ores in the United States.—The production of iron ore in the United States occurs in four main sections; namely, the northeastern states, southeastern states, the Lake Superior district, and the western states.

The northeastern section.—The two principal areas of iron ore production in the northeastern states are the Adirondack district of New York and the Cornwall district of Pennsylvania. The latter extends across New Jersey into southeastern New York and is often referred to as the southeastern New York-New Jersey district. The total output of ore in the northeastern states has been somewhat in excess of 2,200,000 tons annually during normal years. Magnetite, the principal ore, has a relatively high market value per ton because of its quality and its accessibility to markets. The ores of New York and eastern Pennsylvania are of importance as local sources for the ore smelting industries in northeastern United States, although the

total production is relatively small compared with that of some of the other areas.

The southeastern section.—The southeastern section includes all the territory south of the Potomac and Ohio Rivers and east of the Mississippi. The only important mining districts are in the vicinity of Birmingham, Alabama, and Chattanooga, Tennessee. The total output of ore of these two districts is about 6,500,000 gross tons annually, subject of course to fluctuations in various years. Hematite is the principal ore, but associated with it are also considerable quantities of limonite. The Birmingham and Chattanooga centers have the ad-

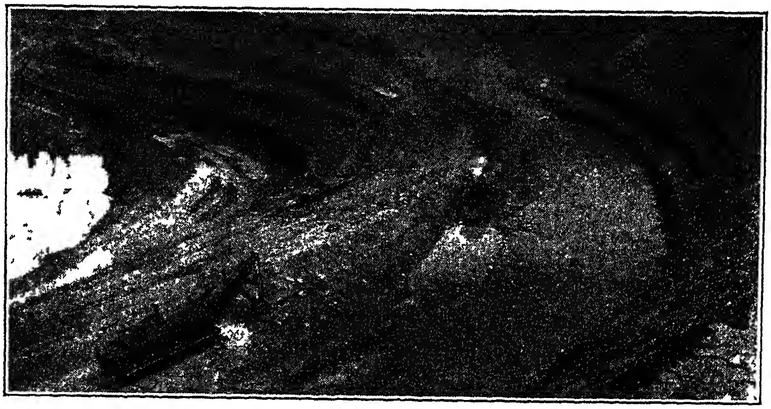


Fig. 132.—Part of open-pit iron mine at Hibbing, Minnesota, Mesabi Range. Note different levels, steam shovel, ore train.

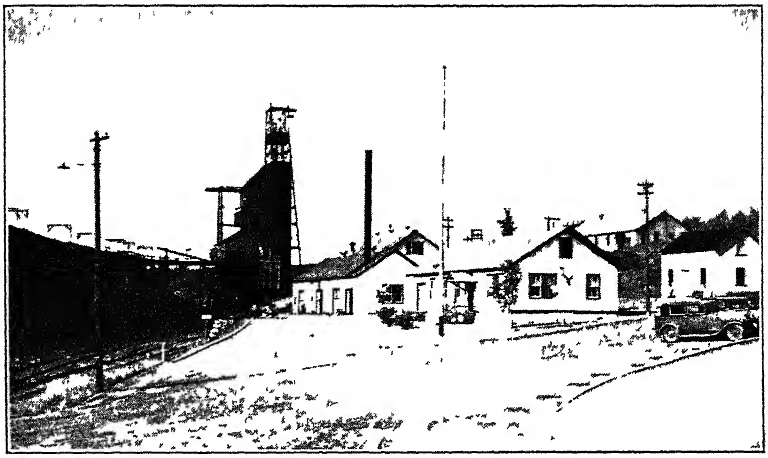
vantage of nearness to the coking coal found in the Appalachian Plateau immediately westward. These centers meet important demands for iron in southeastern United States.

The Lake Superior section.—While the Lake Superior section includes all the territory adjacent to the Great Lakes; the producing area is limited to the peninsula of upper Michigan, northern Wisconsin, and northern Minnesota This area regularly furnishes 80 to 85 per cent of the total iron ore output of the United States Hematite is the predominant ore, occurring in large bodies and generally soft enough to be mined with but little use of explosives The greater part of the output comes from long low hills known as ranges, the principal ones being

the Mesabi, Vermilion, and Cuyuna in Minnesota, and the Penokee-Gogebic, Marquette, and Menominee ranges of Wisconsin and Michigan. The Mesabi is by far the most important, in most years accounting for more than 50 per cent of the total output of the United States.

The average amount of ore mined annually in this district during the six year period 1923 to 1929 was 54,350,000 long tons.

The western section.—The western section includes the iron ore producing centers of Wyoming, Utah, New Mexico, Colorado, Montana, and California. The ore from Wyoming, New Mexico, and Colorado, and most of Utah's production, is used in the manufacture of pig iron, whereas that from other states is used mostly as a flux in the smelting operations of copper and precious metals. The average production of all the western states ordinarily does not greatly exceed 1,000,000 tons per year. The ore of this section is valuable in furnishing the raw material for local industries.



Courtesy, M. A Hanna Co, Cleveland, Ohio

Fig. 133 —Surface plant of underground mine. Note stock pile of iron ore to the left. These stock piles, accumulated usually during the winter season, are characteristic of the underground mines. Iron County, Michigan, Menominee Range.

Summary of iron ore production in the United States.—The average annual output of iron ore in the United States during the past decade has been about 60,000,000 tons. The yearly output has been subject to wide fluctuations; for example, in 1921 only 29,500,000 tons of ore were mined, whereas in 1929, 73,028,000 tons were mined. Nevertheless, the average price of ore at the mine has remained at about \$2 00 to \$2.50 per ton for the country as a whole in recent years One reason for this

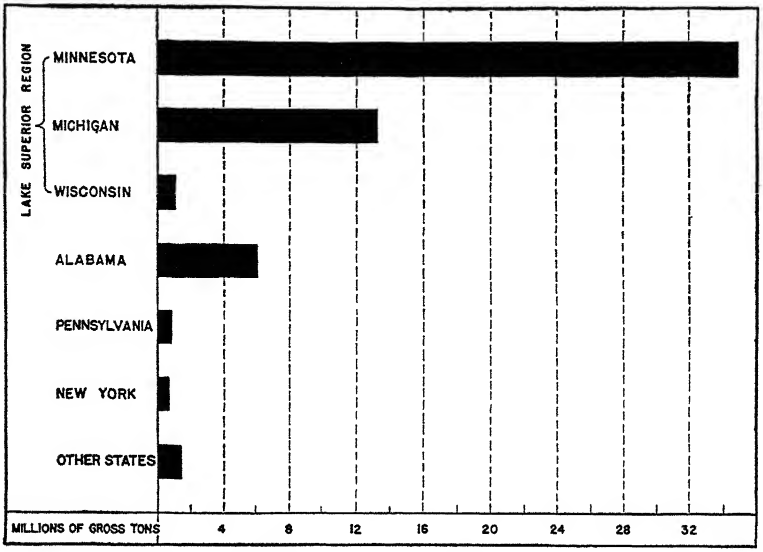


FIG. 134.—Iron ore output of states leading in production. Average 1921-1930. (Source of data *Mineral Resources of the United States,* Bureau of Mines, Washington, D C)

is that the great iron and steel manufacturing companies are the principal consumers, and much of the output is directly owned or controlled by them. In general, more than 95 per cent of the ore mined is hematite. Magnetite usually constitutes about 3.5 per cent of the total, while limonite is third with only 1 5 per cent. The output of siderite is so small as to be almost negligible.

The three states leading in production of iron ore are Minnesota, Michigan, and Alabama, the first named regularly producing more than half the annual output of the entire country

Fourth and fifth places are usually held by Pennsylvania and Wisconsin respectively, while a number of other states produce lesser quantities.

Development of the iron and steel industry of the United States.—While iron ore has been mined within the present borders of the United States since the beginning of the Colonial Period, the growth of the iron and steel industries into giant dimensions has occurred within the last century. The earliest colonists felt keenly the need for local iron supplies. Transportation across the Atlantic was slow; months were required for orders to be supplied from Europe Such delays were costly because needs could not always be foretold long periods in advance. While the New England ores were scarce and of low grade, the bog iron deposits (a form of limonite) found along the coast sufficed for the operation of small smelters, the first of which was built near Lynn, Massachusetts, in 1643 Others followed soon after, so that by the end of the seventeenth century New England boasted a sizeable iron industry. The output was used chiefly for the manufacture of iron fittings for ships, agricultural implements, builder's hardware, and iron kettles The last named were indispensable in the household economy of the times for cooking purposes, for rendering lard, and in making home-made soap For these and similar purposes iron was essential, but demands were not large because wood was the material most used in the construction of ships, implements, carriages, homes, and business structures.

The steam engine preceded the building of the factories and railroads, and with all of them came the rapidly growing demand for iron and steel. The small deposits of impure bog iron were inadequate to meet the enlarged demands. Then richer deposits found in New York, Pennsylvania, and Maryland were exploited with the result that numerous iron and steel plants were developed there, and that section became the chief center of the iron industry of the United States. Nevertheless, the output was insufficient to meet the expanding demands, and large imports from Europe continued Charcoal was depended upon for smelter fuel during the early stages of this develop-

ment. It was later supplanted by anthracite coal. The advantage of northeast Pennsylvania in availability of anthracite made it the leading center of the iron industry until after the Civil War. The expansion of factories and of railroad construction gave rise to splendid markets for iron and steel By 1860 American mills were turning out over 200 000 tons of iron

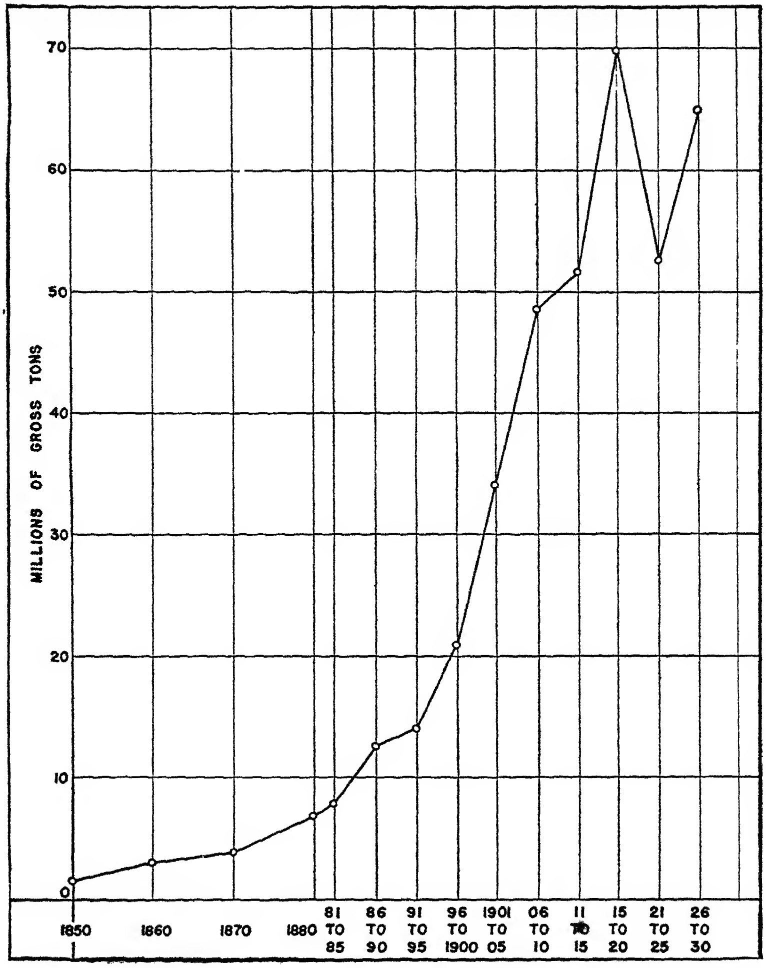


Fig. 135.—Iron ore production in the United States since 1850. (Source of data: *Mineral Resources of the United States*, Bureau of Mines, Washington, D. C.)

rails per year. The development of the West created great markets for iron and steel products at about the same time that the exploitation of the iron ore resources of the Lake Superior district began These factors, together with the shift in smelter fuel from anthracite to coke made from bituminous coal, caused the center of the iron industry to shift westward beyond the Alleghenies Pittsburgh became the nation's "iron and steel capital," a position it still holds in the public mind.

Measured by present standards, growth was slow until after 1880. In 1879 the total amount of ore mined in the United States was but 6,307,883 tons, compared with 73,028,000 tons in 1929. Since 1880 we have quite literally entered upon a steel age. Wood has been almost entirely displaced by steel in the construction of ships, railway cars, motor vehicles of all kinds, agricultural machinery, and in factory equipment Skyscrapers are gigantic steel structures wherein but little wood is used. Even furniture and office equipment are made largely of steel. In every productive industry of any importance steel is an essential So closely related is the iron and steel industry to all other commercial enterprises that it is generally regarded as the foremost business barometer; the trend in the iron and steel trade is accepted as a reliable index of business In its evolution in the United States from the small beginnings of the seventeenth century, the centers have shifted inland from the Atlantic coast to eastern Pennsylvania and thence beyond the Alleghenies Before considering the problem of further trends to be expected, let us view the present situation

Iron and steel centers.—There are now a few centers of universally recognized leadership in iron ore smelting and the manufacture of iron and steel, the foremost ones being the Pittsburgh-Youngstown and the Gary-South Chicago centers. The Lake Erie cities from Buffalo to Detroit, beyond the lake proper, may be considered to be an extension of the Pittsburgh district, the two having many factors in common. Taken together, the output of iron and steel from the plants on or near Lake Erie and from those at the head of Lake Michigan constitutes by far the major part of the production of the United States.

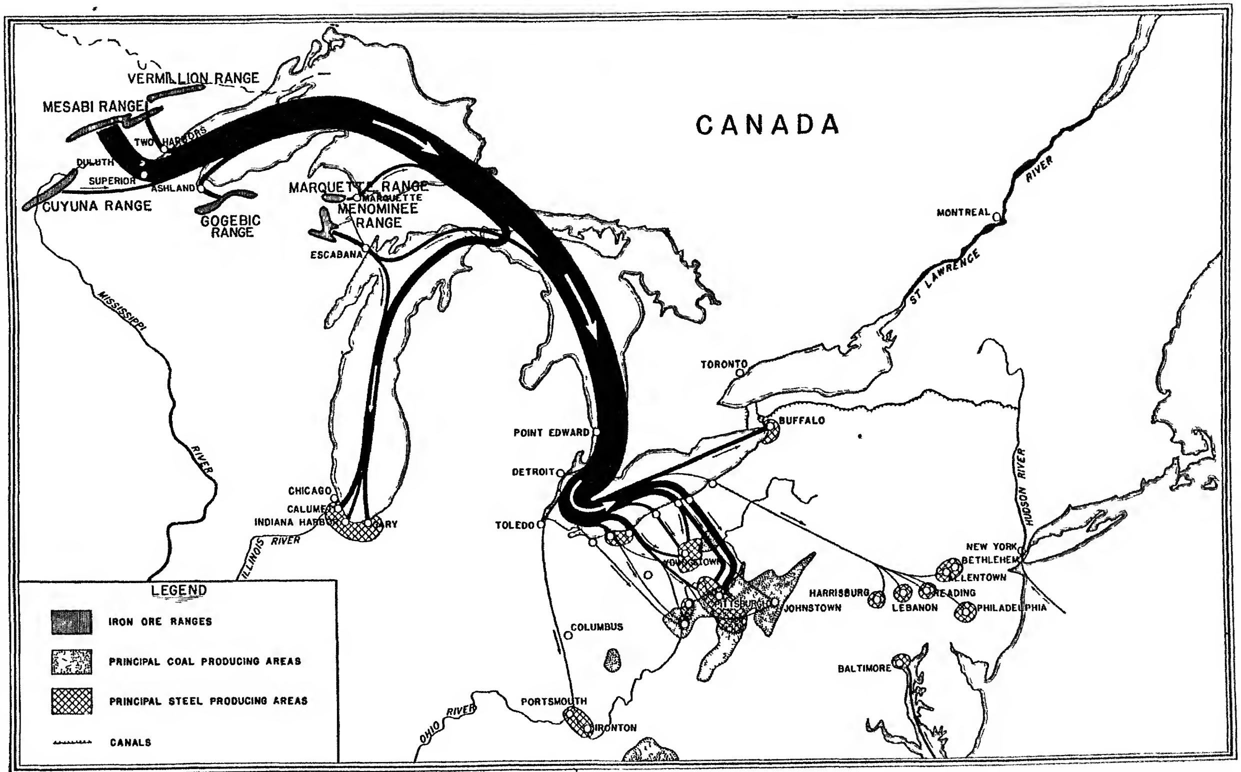
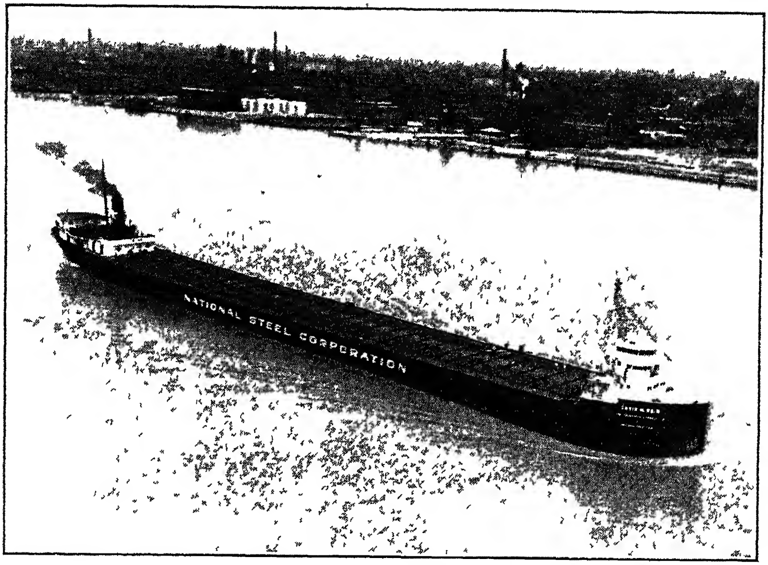


Fig. 136.—Production and transportation of iron ore in the United States. Average 1924–1928 (Sources *Transportation on the Great Lakes*, War Department and U S Shipping Board, *Mineral Resources of the United States*, Bureau of Mines, Washington, D C, and Iron and Steel Institute)

Iron ore transportation in this country is dominated by the Great Lakes water route, supplemented by short rail haulage from the lake shores to the smelters. Lake transportation is cheap, and therefore, even though distances are relatively great, the ore is available at low cost for the coal of the Pittsburgh-Youngstown district and for that of Illinois. The importance of the Great Lakes can hardly be over-emphasized in accounting for the prominence of the great iron manufacturing cities from Pittsburgh to Chicago



Courtesy, M A Hanna Co, Cleveland, Ohio

FIG. 137.—A Typical Ore Boat for Traffic on the Great Lakes. The flat-decked boats have almost entirely displaced the old-fashioned whale backs.

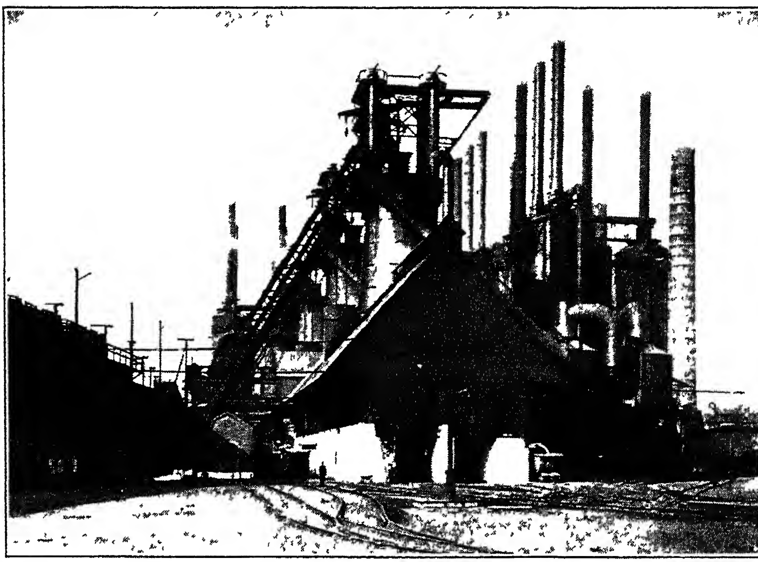
The Pittsburgh-Youngstown district.—The leadership of the Pittsburgh-Youngstown area must be attributed, however, to several factors other than that of lake transportation, among which the importance of an early start must not be overlooked Prior to the great exploitation of Lake Superior ore, Pittsburgh had achieved prominence in the iron industry based on the smelting of ores mined nearby. The bituminous coal in adjacent mines was found to make coke of excellent grade, and an

abundance of natural gas furnished the cheapest and most efficient fuel for steam purposes. These advantages enabled Pittsburgh to wrest supremacy in the iron and steel industry away from eastern Pennsylvania and to hold it west of the Alleghenies Compared with the newer centers farther west, Pittsburgh has some advantage in her nearness to the great eastern markets, and this, combined with her early start, has retained for her the position of supremacy in the face of keen competition The Youngstown-Pittsburgh district ranks as one of the greatest iron smelter and steel mill centers in the world, and it is axiomatic that business men of Europe as well as those of the United States view the activities of the iron and steel plants there as being among the foremost business indexes of the nation.

The Chicago district—Ranking second to the Youngstown-Pittsburgh district is the Chicago district, at the head of Lake Michigan, including the cities of Gary, Indiana Harbor, and South Chicago The Chicago district is favored by ore cheaply available, by low cost coal for heat and steam, and by great interior markets. The railroad demands for rails and rolling stock have been heavy because of the vastness of the territory served The recent growth of cities in the interior has called for quantities of structural steel. Located in the heart of grain farming America, Chicago is the natural source for furnishing the iron and steel needed in manufacturing agricultural implements With all these advantages, two serious disadvantages, compared with the Lake Erie-Pittsburgh area, must be faced; namely, more restricted markets and lack of high quality coking coal. The coal used for heat and power comes mostly from Indiana and Illinois This is a splendid low cost steam coal, but is not of good coking quality It is necessary, therefore, to depend on coke from the Appalachian bituminous fields of Pennsylvania and West Virginia. And the markets for iron and steel from the Chicago area are not equal to those of the Lake Erie-Pittsburgh area; the latter are unsurpassed because they serve not only the most densely populated section of the United States, but also most of the nation's shipbuilding yards located

near the eastern seaboard. Although the Chicago district may not attain supremacy in the iron and steel industry of the United States, its natural advantages are so great and its trade area so large that its present high rank seems assured.

The Lake Superior district.—The upper Lake Superior district is of course primarily noted for ore mining and shipping, not for iron smelting. Duluth has, however, a sizeable iron industry, because of the low haulage rates on coal carried by the



Courtesy, Bethlehem Steel Co

FIG. 138.—A blast furnace wherein ore is reduced to pig iron. Note the inclined skip whereby coke, limestone, and iron ore are conveyed to the charging platform at top of furnace. Batteries of stoves shown at right of the blast furnaces.

ore boats on their return trips from Lake Erie and Lake Michigan ports. An important industry has thus been developed on the basis of nearby ores, coal cheaply available in spite of remoteness, and markets in the northwest readily served from Duluth as a distributing center.

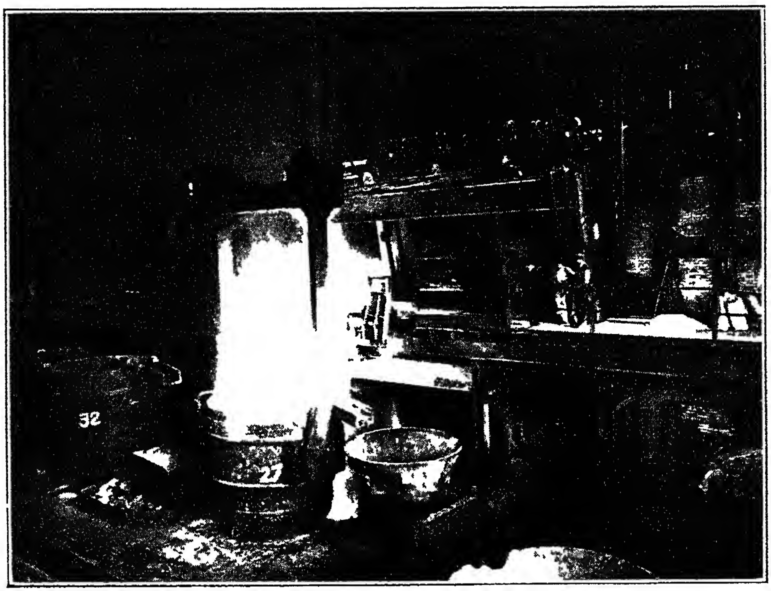
The Birmingham district—Birmingham, Alabama, is called the "Pittsburgh of the South" While this title is hardly justi-

fied, because Pittsburgh is primarily a steel city and Birmingham is chiefly a center of production of pig iron and various kinds of malleable and cast iron products, it is true that the Alabama city far outranks all others in the South Chattanooga, Tennessee, is an important second center in the same general area In both cases, iron ore, coking coal, and limestone are close at hand. The availability of these fundamental raw materials has led to the development of a great iron manufacturing industry to serve the needs of southeastern United States more efficiently than they could be served by the plants located farther north. Steel development has lagged because, in the main, the same capital interests which operate the blast furnaces of the southern centers are the owners of the steel plants of the north. Since steel is much more valuable per unit of weight than is pig iron, and since the mills of the north have the capacity to turn out more steel than the whole country demands, capital has not deemed it economically wise to attempt large scale steel production in the southern centers The outlook justifies the belief that, with the development of the South, Birmingham and Chattanooga will continue to expand as iron producing cities, but that the steel will be supplied mostly from the old, established northern centers

The Pueblo district.—Pueblo has the distinction of being the only important iron ore smelting city west of the Mississippi River. The ore is mined in southeastern Wyoming, where a high grade hematite occurs in fairly large quantities. Coking coal is obtained from the Trinidad field of southern Colorado, not far from Pueblo. It has been found to be cheaper to bring the ore from Wyoming to Pueblo, near the essential coking coal, than to haul coal to the ore. The markets are of course not nearly so large as are those of the East, yet the diverse needs of the extensive tributary region call for quantities of various kinds of iron and steel products The mines, railroads, cities, bridges, and local factories and smelters combined make a larger market outlet than one would think of when considering the "vast open spaces" Because of available reserves of coal and iron ore, and the growing markets of the industrial development

of the West, Pueblo can be expected to maintain its place as an important iron and steel city.

Other districts.—Although the principal centers of the American iron and steel industry have long been west of the Alleghenies, some of the older eastern districts have maintained positions of importance. When anthracite was the chief smelting fuel, eastern Pennsylvania became the foremost iron and steel center in the country. When coke from bituminous coal



Courtesy, Bethlehem Steel Company

Fig. 139.—Interior view of an open hearth steel plant. Shows tapping of molten steel from converter into ladle. Size of equipment indicated by comparison with men on platform

displaced anthracite and the Pittsburgh district forged to the front, the established iron and steel plants near Harrisburg, Allentown, and Bethlehem found it necessary to turn to high quality specialty manufactures Operators found therein a profitable field of business. High grade ores are furnished by the mining areas of the Adirondacks and northeastern Pennsylvania. Only a relatively short haul is necessary to bring coke and coking coal from the producing areas of the west. The

densely populated territory from Boston to Richmond serves as a front door market of first magnitude for quality steel goods varying from steel rails and armor plate to the finest cutlery steel for razor blades This combination of favorable factors—namely, available ore resources, low cost fuel, and great adjacent markets—gives assurance of continued prominence of the Allentown-Bethlehem district in the iron and steel industry.

The Atlantic seaboard, the scene of the earliest iron industry in the colonial period, is apparently undergoing a renaissance that may again give it high rank Foreign ores can be shipped there by all-water routes, and much scrap iron is obtainable from the nearby manufacturing and transportation industries. These conditions, together with the great markets, have led to the development of specialized iron and steel manufacturing in the coastal cities from New York to Boston, and one of the largest plants in the country is located at Sparrows Point, Maryland, on Chesapeake Bay. The Atlantic coast cities, particularly in the Baltimore district, are quite likely to become of increasing importance in the American iron and steel industry during the next quarter of a century.

Iron ore resources of foreign countries.—Inasmuch as iron is one of the most common elements of the earth's crust, it is quite natural that ore bodies of this metal should be widely distributed At present only those most favorably located with respect to transportation, power resources, and market demands are being utilized Large reserves of iron ore exist in Asia, Africa, South America, and Australia, but investigations have not proceeded to the point where definite details are known. Among the important and well known reserves, now but slightly exploited, are those of Chile, Cuba, and eastern Brazil Each of these countries is producing some iron ore, but not on a scale commensurate with that which is characteristic of the intensively worked deposits of the United States and Europe. This discussion is limited, therefore, to those countries wherein extensive ore mining is in progress and to the countries having well developed iron and steel industries.

The United Kingdom.—England and Scotland have extens-

ive bodies of ore, but the percentage of iron content is low. Consequently there is a growing tendency in Britain toward increasing dependence upon higher grade imported ores. In 1913 the United Kingdom stood fourth in the list of producers of iron ore; her output was approximately 15 5 per cent of the European production and she consumed about 21.5 per cent Since then the proportion of imported ore has increased. Late data indicate that more than 30 per cent of British iron and steel production is based upon imported ores. Most of the ore

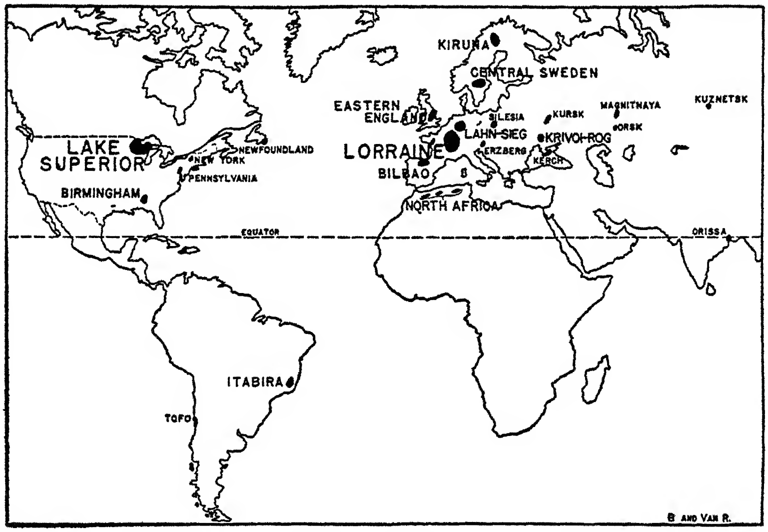


Fig. 140 —Principal iron ore producing regions of the world.

is obtained from France, Spain, and Sweden, while smaller quantities are imported from North Africa and southern Russia.

Although but little progress has been made during the past decade, the position of Great Britain in the iron and steel industry of the world is high and will continue to be so because of the factors favoring the industry In the first place, there is a large and well established home market growing out of the great manufacturing, transportation, and shipbuilding industries. The British people are heavy users of iron and steel

products, in part because of the relative scarcity of wood Furthermore, the high quality of British products established world markets at an early date, and the momentum thus gained continues to be an important business factor. On the other hand, the industry is confronted with such problems as the increasing cost of coal and of imported ores. Furthermore, it must contend with exceptionally strong labor unions whose dominance is not always favorable from an economic standpoint, because of the competition which British products must face in world markets. Another factor is the characteristic conservatism of the British industrialists. In many cases the management of the plant passes in succession from father to son, and this tends toward relatively slow improvement of methods while it is at the same time a strong factor for the permanence of individual manufacturing establishments

In recent years Great Britain has been contributing seven to eight per cent of the world's output of pig iron, while in the years immediately before the Great War her output constituted 12 to 14 per cent of the world's total. It is therefore clear that she has not maintained her relative position, even though the total output has not suffered serious decrease

France —From the standpoint of known iron ore resources, France ranks foremost in Europe and second to the United States among the nations of the world. The centers of production are in the Lorraine Basin of eastern France and in Normandy and Brittany in northern France, the former accounting for about 97 per cent of the total output of the country. A large part of the Lorraine district passed into the control of Germany in 1872 as a result of the Franco-Prussian war, and was so held until 1919. The ores are mainly hematites and limonites of comparatively high content of phosphorus and of earthy materials In earlier years the high percentage of phosphorous deterred development, but when, after 1878, methods of converting high phosphorous pig iron into steel were perfected, the value of the Lorraine ores was greatly increased.

The French output of iron ore has expanded greatly since the

1914

World War, in some years exceeding 40,000,000 tons, or more than 10 per cent of the entire world production The mining industry has profited not only by the increased domestic demand, but also by strong foreign markets which have taken nearly 50 per cent of the total ore output. Belgium and Luxemburg receive the largest quantities of the exported ore, being followed by Germany, Netherlands, and the United Kingdom respectively. Prior to the World War the average annual output of pig iron in France was only about one half as great as that of the United Kingdom. Since 1919 the iron and steel industries have made rapid strides owing to the utilization of the Lorraine ores and to the coking coal obtained from Germany as part of the war settlement Rather steady increase in production of pig iron from 2,408,000 gross tons in 1919 marked the succeeding decade so that in 1929 France was reported as having an output of 10,439,000 tons, almost 50 per cent greater than the output of the United Kingdom in the same year

With continued exploitation of the Lorraine ore deposits, and with coking coal available, the iron and steel industries of France give promise of a prosperous future. This depends, however, to a large extent on the availability of cheap coking coal France has already taken steps to become less dependent upon Germany by developing her own deposits in the north and arranging more direct trade relations with the coal interests of Belgium and Holland The fact that the Lorraine ores are mixed with earthy impurities and are therefore relatively low in iron content adds to the possibility that it may prove profitable to ship coal to the ore Consequently, the French iron and steel industry seems to be in a position where it can face open, competitive conditions with reasonable assurance of continued prosperity.

The German Reich—Germany ranks far below England and France in known reserves of iron ore. The accessible ore supplies are mostly in the Slate Mountain district along the Rhine, in western Germany For the present the low grade of the ore is of greater importance than the total available ton-

nage The richest German ores contain only 41 per cent metallic iron, and most of the ore mined has metallic content considerably below 40 per cent Furthermore, nearly all the ores are difficult to reduce to iron. These factors are especially significant in view of the fact that in the United States ores of less than 45 per cent iron are considered to be too low grade for economic use even when they present no difficult smelting problems.

The settlement at the close of the World War gave the iron and steel industries of Germany a hard blow Through it she lost 80 per cent of her iron ore production and about 30 per cent of her steel works and her rolling mills. The reconstruction period since 1919 has been marked by remarkable recovery, however, so that she is again able to compete fully in output and in world trade with England and France From 1922 to 1930 she exported 4,500,000 to 5,500,000 tons of crude steel annually, about 30 to 45 per cent of her total production. The capacity of the industry is such that Germany needs to export at least 25 to 30 per cent of her total output if the equipment is to be gainfully employed

The iron and steel industries of Germany are favored with high quality of coking coal in the northwest part of the country, particularly in the Ruhr district, where access to the ocean facilitates overseas trade and river and canal routes connect with the markets of the interior By these same routes foreign ores can be obtained at relatively low cost of transportation. The loss of political control of the Lorraine province does not, under normal conditions, prevent the industry from obtaining iron ores from that district Germany is thus in a position to obtain ores from various sources—from nearby fields, or from more remote fields by water routes. Even if French supplies were to be cut off entirely, the loss of the Lorraine district would be partly offset by the direct trade contacts established with other sources, particularly those of northern Sweden, whence high grade ores can be delivered at low transportation costs. Germany suffered severe but not fatal losses by the Treaty of Versailles, and we may expect that she will continue

to be one of the great iron and steel manufacturing nations of the world

Belgium.—Belgium has the natural advantages of coking coal, a little domestic ore, other ore supplies readily obtainable, and well developed seaports These advantages, together with an industrious population and an early start, have enabled her to attain a position as one of the foremost iron and steel manufacturing countries of the world, in proportion to size.

The degree to which the Belgian iron and steel industries are dependent upon foreign ores may be inferred from the fact that only 153,800 metric tons of iron ore were mined in 1928, while in the same year the output of pig iron was 3,857 000 tons, and of steel 3,802,000 tons. Belgium has the advantage of easily accessible high grade ores from France and elsewhere and thus its iron and steel industry is another illustration of the "ore to coal" movement which is characteristic of this industry in many places.

The iron exports of Belgium amount to 60 or 70 per cent of the total output Since the local markets are small, the iron and steel industries have been developed largely on the basis of export trade This development is such that Belgium needs to dispose of 65 to 75 per cent of her output in foreign markets if her mills and men are to be gainfully employed

Russia.—During the two decades prior to the World War the Russian government gave definite economic encouragement toward promoting the iron and steel industries of the country Loans were made to finance plants, tax exemptions for limited periods were granted, bounties were paid on exports of pig iron, and the government paid more than market prices for rails bought from Russian manufacturers These policies were carried out because the political leaders believed that the country had the raw materials and the potential markets to sustain an important iron and steel industry As a result of active encouragement by the government and of the favorable factors of resources and markets, a development occurred which by 1913 had placed Russia sixth among the nations in ore output and fifth in the manufacture of pig iron.

In actual known reserves Russia is usually ranked fourth in Europe, being surpassed by France, the United Kingdom, and Sweden. High grade ores, averaging 45 to 55 per cent iron, are plentiful. The two best-known districts are the Krivoi-Rog, in southern Russia, and the southern Urals In the former, coking coal is available without any long overland hauls, but the latter is handicapped by its remoteness from coal, the nearest source of supply being the Kuznetsk Basin, nearly 1,500 miles distant. Other districts occur south of Moscow and along the flanks of the Caucasus Most of the development, however, has occurred in the Krivoi-Rog and the southern Urals; even these must overcome the handicap of relative remoteness from the most densely populated areas of the country.

Since the collapse which occurred at the close of the World War and in the early period of the Revolution, great progress has been made in re-establishing and expanding the iron and steel industries Russia was the only country to expand its output of pig iron in 1932, a year of pronounced economic depression all over the civilized world. In that year she ranked second among the nations, being exceeded only by the United States.

Given wise management, the Russian iron and steel industries seem assured of a future exceptionally bright The necessary bulky raw materials, iron ore, coking coal, and limestone, are available in abundance. The country is of great extent and is in need of an immense building program involving railroads, public highways, factories, business houses, and homes. A population of more than 160,000,000 people has been on a basis of production that has called for much hand labor and for but little use of machinery. New forces are at work, promoting rapid changes The industrial revolution in Russia, long delayed, gives promise of important strides forward Domestic needs will provide markets for expanding industry, and the probabilities are that Russia will be able not only to absorb her own iron and steel output, but will be in need of large imports for some years to come.

Poland.—The available ore reserves of Poland are small and

of relatively low iron content, averaging below 30 per cent. The poor quality of the ore has always been a handicap to the exploitation of the domestic supplies. Even during the pre-War period, iron ores were imported from southern Russia, 700 miles to the south, to the Polish iron and steel centers This handicap is offset however by the presence of large quantities of coking coal.

Notwithstanding the increase in ore mining during recent years, Poland still imports more than one half of her needs. The domestic ores are mixed with those of higher grade imported from Soviet Russia, Sweden, and Morocco. In recent years the imports have been slightly below the tonnage of domestic production, but because of their higher quality the actual amount of metal derived from them has exceeded that obtained from the domestic sources.

A gradual increase in production of iron and steel manufactures will probably continue for some years to come Coking coal is available, iron ores can be obtained easily, and markets will probably expand with the development of industrialism in the country itself and in Russia These trends now in progress bespeak a moderate growth of the Polish iron and steel industry

Sweden —Sweden has increased her output of iron ore steadily during the past two decades The deposits lie in three distinct geographic regions; namely, southern Sweden, central Sweden, and Lapland in northern Sweden The southern ores are now of little significance to the industry as a whole, although in former years they were quite important in furnishing raw materials for small local plants The central district was exploited first and is still yielding an annual output of about 1,000,000 tons Much of this ore is used by the smelters of Sweden, and only limited quantities are permitted to be exported The largest reserves of magnetite in Europe are in in Swedish Lapland. The ore is high grade, containing 60 to 70 per cent of iron. The centers of development are north of the Arctic Circle, at Kirunavaara and Gellivaara The known Swedish reserves are given as about 2,203,000,000 tons of which more than half are at Kirunavaara alone.

The annual production of iron ore in Sweden is normally 10 to 12 million tons, of which 85 to 95 per cent is exported. The principal markets are in Great Britain and Germany, but considerable quantities are also exported to the United States.

The iron and steel manufacturing industries suffer from the lack of coking coal, but this handicap is overcome in some measure by the availability through water transportation of coal from England and Germany. On the whole, marked success has been achieved through emphasis upon skill of workmanship rather than upon bulk of output. The industries are expanding and prospering because of specialized production, particularly of cutlery, ball and roller bearings, and of high grade tool steel. Efficient business organizations are making energetic efforts to develop foreign trade. The future of the Swedish iron and steel industry seems, therefore, to be secure, but it must be built upon the basis of skill in workmanship and quality of products, to meet specialized demands, rather than upon the basis of magnitude of output.

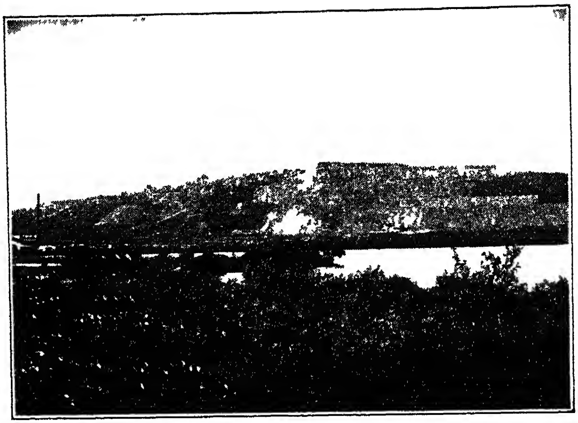


Photo by N A B

Fig. 141.—Iron ore mine at Kirunavaara, Sweden The open-cut method of mining is used.

Spain.—In known reserves of high grade iron ore, Spain ranks among the most favored countries of Europe. The Cantabrian mountain range along the north coast is estimated

to contain over 30 per cent of the country's total reserves, and it now furnishes more than half of the annual out-put. Other important ore bodies are known to exist along the flanks of the Sierra Morena and the Sierra Nevada mountains of southern Spain

The iron ores now being exploited are of high quality, the metal content being 50 to 60 per cent. Bilboa on the north coast is the principal export city, with England and Germany the greatest markets. Inasmuch as the iron and steel centers of these countries are close to the seaboard, the cost of ore transportation by practically an all-water route is low; this is a factor of distinct advantage to producers in Spain as well as to purchasers in northwest Europe.

Although Spain is one of the great ore-producing nations of the world, a large-scale iron and steel industry has not been developed. In this respect it resembles Sweden. Both countries have large stores of ore but are weak in industrial coal and must, therefore, face the futility of attempting world-wide competition in the lower grades of manufactures. However, each has important local markets which can be supplied advantageously. The future of the iron and steel industry of Spain will probably be limited to some lines which serve local needs and to specialized fields of manufacture wherein skill is at a premium

Other European countries.—Iron and steel manufacturing is of economic significance in almost all European countries, and the mining of iron ore is important in a number of them. In addition to those already discussed, Norway, Italy, Austria, and Czechoslovakia have mining and manufacturing interests of high rank. Norway has fairly extensive deposits of iron ore but, on account of poor quality, finds it difficult to compete with Spain and Sweden in supplying ore to foreign markets. Italy has considerable quantities of ore but is dependent on foreign coking coal. Austria is handicapped by lack of a large domestic market and by tariff barriers which impede exports to adjacent countries Czechoslovakia is fortunate in having iron ore, coking coal, and important domestic markets. These ad-

vantages, combined with easily available supplies from adjacent countries and a well established foreign trade, place the country in a favorable position for future development

The iron ore resources of other continents and countries.—Authentic information concerning Africa is difficult to obtain. In northern Africa there are extensive deposits of iron ore, and considerable development has occurred in Morocco and Algeria, with lesser development along the coast farther east Extensive bodies of low grade ore (25 to 30 per cent) have been discovered in Rhodesia, and higher grade ores (45 to 60 per cent) in the Union of South Africa Exploitation of the latter is in progress, and an active iron and steel industry is being developed to supply local needs.

The extent of the reserves of Asia is not well known Mines are in operation in China and Chosen, and large stores of ore are known to exist in Siberia and in India. Japan's domestic reserves are not large, but she has a well developed, highly efficient iron and steel industry which utilizes iron ore and coal from China and Manchukuo to supplement the domestic supply of raw materials Although Japan has both ore and coal in sufficient quantities to maintain the iron and steel industry for some time even if foreign supplies were to be cut off, the quality is so poor that economic operation would be difficult

India appears to be Asia's favored country in known stores of iron ore, far outranking China in this respect. During the past decade she has progressed greatly in her ore output and also in the manufacture of pig iron and finished steel, the quantities of each having practically trebled since 1920 India is an important exporter of pig iron to Japan, her foremost customer, and to the United States, United Kingdom, and Germany

The resources of South America have not been adequately studied Large deposits have been discovered in eastern Brazil and on the west flank of the Andes in Chile The principal deposits of Brazil are found in the Minas Geraes district, north of Rio Janeiro, where studies thus far made prove the existence of a huge ore body containing over 45 per cent of iron under

exceptionally favorable mining conditions, with a short haul down to the seaboard. Development is quite largely in the hands of foreign capital, particularly American, and it is expected that more than 3,000,000 tons of iron ore will be mined annually within the next few years. It has been reported that at least five per cent of this amount must be smelted in Brazil, for which purpose coal will be admitted duty free. To promote exploitation of the ore, reduced export duty rates have been agreed upon. In Chile a large American steel corporation has obtained exclusive rights to one of the most valuable ore deposits, and active exploitation has been in progress for several years. This ore is shipped to the United States to supply the needed raw material for furnaces and steel plants located at or near the Atlantic seaboard, the largest of which is at Sparrows Point Maryland, near Baltimore Chile is, however, also encouraging the development of a local iron and steel industry to serve her domestic needs, and the near future will probably witness considerable progress in this line. Other centers of iron ore undoubtedly exist in South America, but the Chilean and the Brazilian are best known and the only ones where active exploitation is in progress.

It is believed that Australia and the other islands of Oceania have important reserves of ore, although they may not constitute a high percentage of the world's total. The iron and steel industry in Australia has been developed chiefly to meet local needs. While both coal and ore are present in relative abundance, industrial development is handicapped by lack of extensive markets.

On the basis of studies thus far made, it is estimated that the world's reserves of iron ore are sufficient to supply iron for more than a thousand years at the present rate of consumption. On the other hand, the rate of production of ore and consumption of iron will probably increase, and the period of readily available ore will be shortened much below 1,000 years unless additional reserves are found through further exploration In view of the vast areas for which detailed data are not now available, the probabilities are that such reserves will

be found. It seems fairly certain, therefore, that the iron ore resources of the world are sufficient to meet the demands of the next ten centuries, but that with continued exploitation mining difficulties will become greater and the costs of obtaining the ore will probably rise

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uses were limited by its softness, but the discovery was made that by fusing it with tin, also occasionally found as a metal, a substance much harder than either was obtained This substance, which we now call *bronze,* was far superior to stone previously used as the material for making tools and weapons, and its long-lived popularity is indicated by the term. *Bronze Age.* For many centuries the use of copper and bronze represented the highest form of industrial achievement. Copper was used alone where hammering into desired shapes was essential, as for pots and pans and ornaments, and in alloys with other metals where hardness was desired. It was used for coins because of its durability and the ease with which symbols could be stamped upon it Although from very early times it ranked among the most desired metals, the demand grew but slowly until the development of the electrical industries gave rise to an unprecedented need for copper in connection with the generating and the transmission facilities.

In a modern sense, the age of electricity might also be called the age of copper because of the uses made of the metal and its alloys These uses are made possible by several essential properties of copper, most important of which is its conductivity of electrical energy Of almost as great importance are its ductility and its malleability. The former makes possible the fine copper wire now essential in electrical equipment, while the latter permits hammering into plates and sheets Furthermore, copper does not rust, does not weather, and it may be extensively used in alloys

Copper ores.—Ores varying from native copper to complex chemical combinations are found in formations of nearly all geologic ages Generally the ores of copper are more complex than are those of iron and, because of the presence of large quantities of impurities, they do not contain the percentages of metal indicated by their chemical formulae Some of the largest and most important mines are yielding ores which contain only one to three per cent recoverable copper, while ores which yield nine per cent or more are deemed to be exceptionally rich

The distribution of copper mining in the United States.—Nearly 85 per cent of all the copper mined in the United States comes from Arizona, Utah, Montana, Michigan, and Nevada Other states having somewhat important production are New Mexico, California, and Tennessee In a number of places copper is a valuable by-product of ores mined chiefly for their content of other metals.

The average annual copper production in the United States from domestic ores reached the astounding figure of nearly 1,800,000,000 pounds during the period 1926-1930 Arizona

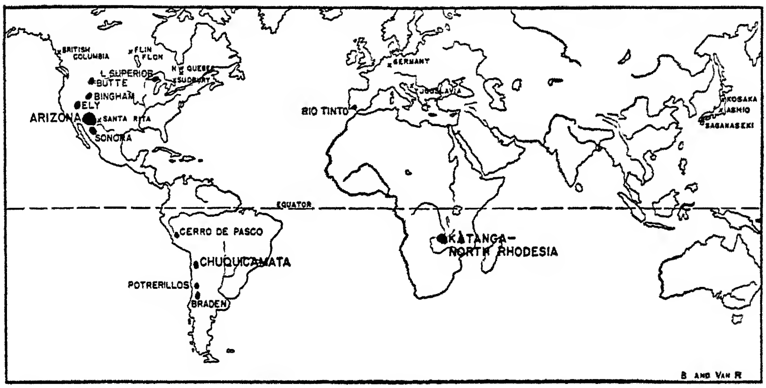


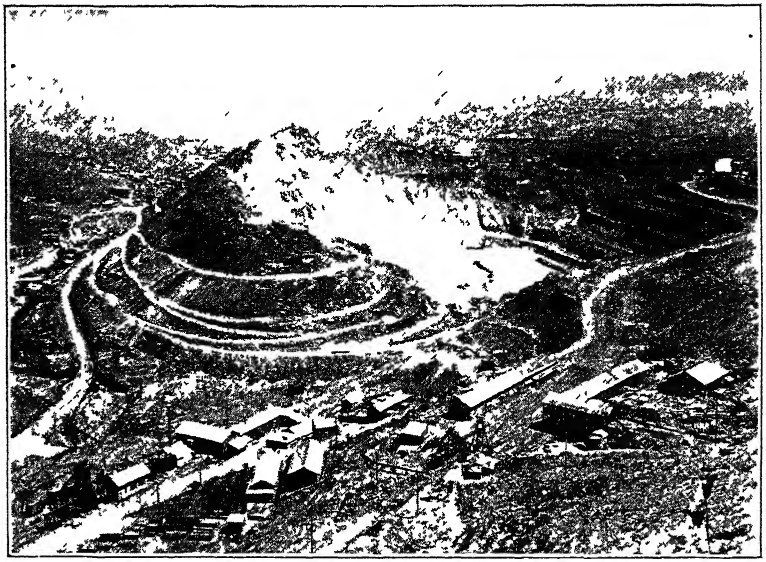
FIG 142.—Principal copper producing regions of the world.

has consistently maintained a commanding position, producing on the average more than 700,000,000 pounds of copper in normal years States ranking next in output, although not always in the same sequence, are Utah, Montana, and Michigan.

The greatest copper producing districts of Arizona are in the southeastern part of the state, from the Mexican border northward to beyond Tucson. In this area the Globe, Bisbee, and Jerome districts have become familiar names to those interested in the copper industry. The ore bodies vary from massive, low grade ores available by open cut, surface mining to those of higher grade but of much more restricted extent. While the three districts named are the largest and best known, there are

also a number of smaller districts being actively exploited, the total output giving Arizona unquestioned supremacy among the copper producing states This rank seems assured for many years to come because of the large reserves known to exist in that state.

The principal producing center of Utah, known as the Bingham Canyon district, is located about 20 miles southwest of Salt Lake City The copper content of the ores averages only



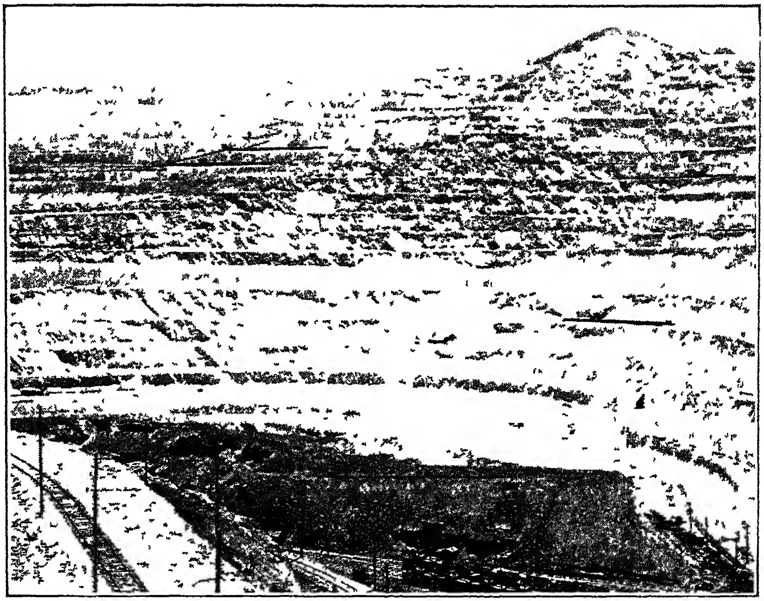
Courtesy, Phelps Dodge Company

Fig. 143.—Open-pit copper mine, Sacramento Hill Pit, Bisbee, Arizona.

one per cent or less, but such large-scale operations can be carried on that even this low grade ore has proven highly profitable The annual copper output in normal years has averaged about 250,000,000 pounds The amount of ore still in reserve gives promise of the continuance of Utah's high place in the copper mining industry of the United States

Montana ordinarily ranks third in annual copper production. The chief center of mining operations is the world-famous Butte district, in the heart of the Rocky Mountains. Although large-scale production has been maintained for several

decades, the proven reserves of ore warrant the belief that mining will continue to be important for many years to come The smelting center for the Butte district is at Anaconda, while a large refinery is located at Great Falls, east of the Rockies, because of the cheap hydro-electric power which is available there. The average copper output of the state in normal years may be expected to exceed 200 000,000 pounds



Courtesy, Utah Copper Company

Fig. 144.—Copper mine at Bingham Canyon, Utah. Note the numerous levels, the tracks, electric shovels, and ore trains being loaded.

The northern peninsula of Michigan has long been noted for its output of copper. Prior to exploration by the whites, the Indians had learned to make some use of the native copper which was found in small bodies in the glacial drift and among the gravels of streams flowing out from the highlands. To the French explorers who came to this region the Indians told stories of hills of copper back from the edge of Lake Superior. Later these uplands became one of the greatest copper producing districts of the world. The ore consists of rock impregnated

with metallic copper. For many years Michigan ranked first in output of copper, but this position was lost with the large developments in the western states. Michigan now generally ranks fourth, being exceeded by Arizona, Utah, and Montana Owing to the mounting costs of production, Michigan seems likely to drop lower in the scale within the next decade

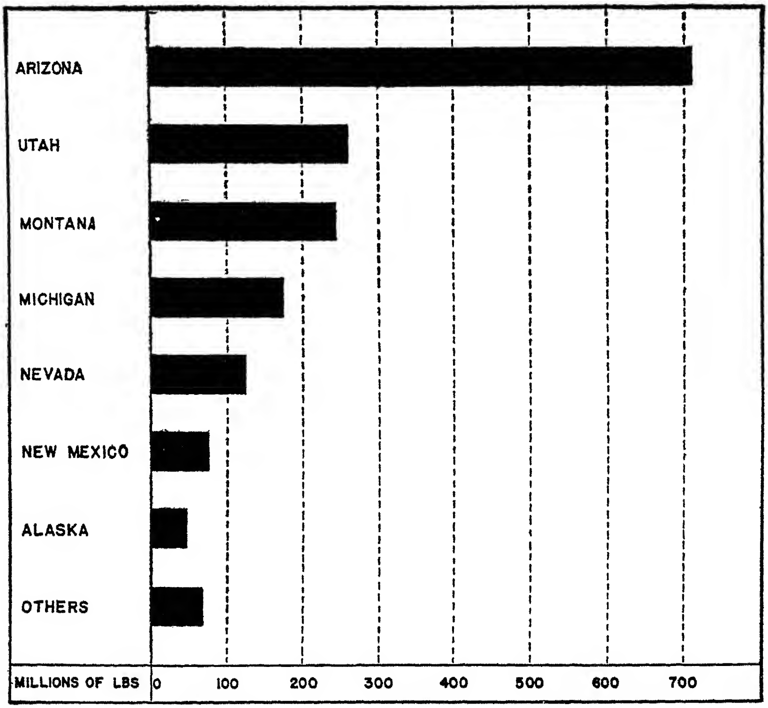
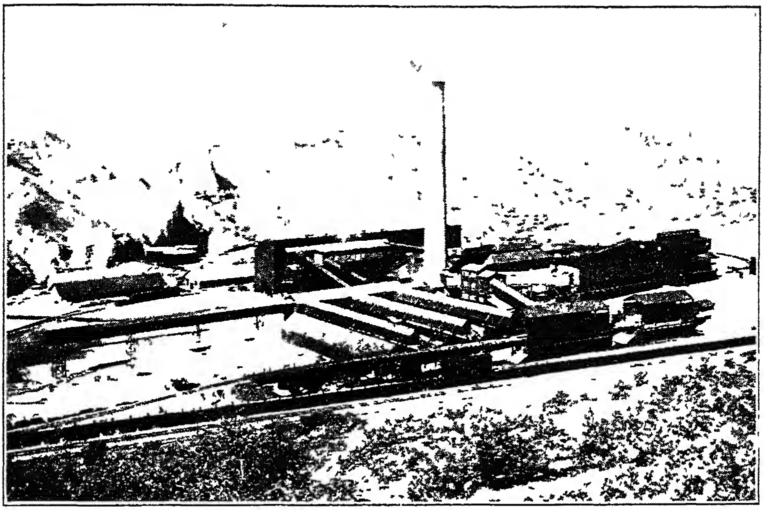


FIG. 145.—Mine production of principal copper states. Average 1926-1930 (Source of data *Mineral Resources of the United States*, Bureau of Mines, Washington, D C)

Distribution of copper smelters.—Because of the large amounts of impurities with which the copper ores are invariably associated, the percentage of metal is always low. Thus the ores as mined yield only from one to eight per cent copper, whereas the iron ores mined in the United States yield from 40 to 65 per cent iron. Copper *smelters* must therefore be located near the mines, because the ore is too bulky in relation to value

to bear the expense of long haulage At the smelters the ore is reduced to "blister," which contains about 98-99 per cent metallic copper For many purposes, however, especially for use in the electrical industries, the metal must be almost pure The processes of purification take place in the refineries where, by electrolytic methods, the impurities are reduced to the point where the copper contains only a few hundredths of one per cent of foreign matter. Expensive equipment and cheap electric power are required for successful operation of the refineries,



Courtesy, Phelps Dodge Company

Fig. 146 —Copper smelter at Clifton, Arizona

which are usually so large that each can handle the copper blister from several smelters

In the United States most of the copper refineries are located at the Atlantic seaboard, close to the centers of consumption. In addition to their supplies from American smelters, these refineries receive copper in various forms from foreign sources, particularly from Canada, Chile, Mexico, Cuba, Peru, and Spain Refineries have also been established in connection with a few of the largest American mining properties, notably at Great Falls, Montana and at Hubbell, Michigan

Copper production in foreign countries: *Chile.*—The copper industry of Chile has expanded rapidly in recent years. The annual output has increased more than five-fold since 1913, an expansion due largely to the investment of large amounts of American capital and the installation of modern equipment for

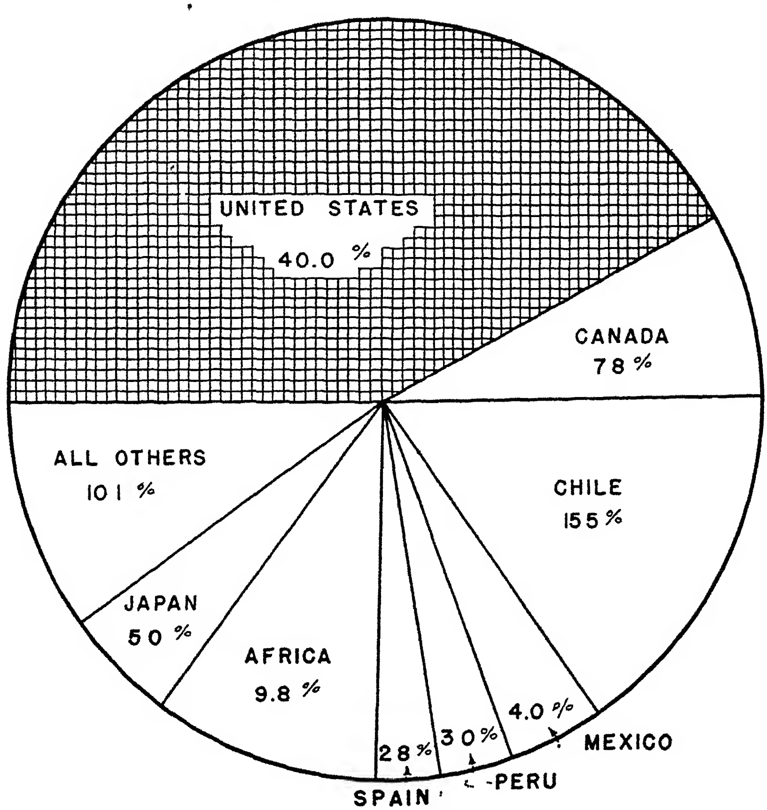


Fig. 147—Mine production of principal copper countries of the world. Average 1928-1932. (Source of data *The Mineral Industry*, edited by G A Roush)

economic exploitation. The industry is favored by low operating costs made possible by extensive operations in ores easily mined and refined The principal centers of copper production are Chuquicamata, Potrerillos, and Braden.

In view of the fact that the ore reserves, proven and prob-

able, are very large, the copper mining industry of Chile seems assured of long life The ore bodies occur along mountain flanks near the sea Ocean haulage is within easy reach, an important factor in obtaining needed supplies as well as in furnishing cheap outlets to the world's markets For these reasons the upward trend of production seems likely to continue and Chile's position as one of the leading copper producing countries of the world seems well established.

Africa—The principal copper producing districts of Africa are in the deep interior, where rainfall is plentiful, quite in contrast to the seaboard location and the desert conditions which characterize the Chilean ore fields The remoteness of the African copper mines from low cost ocean haulage is compensated by the greater richness of their ores. The foremost center of production is in the southern part of the Belgian Congo territory commonly known as the Katanga district. In northern Rhodesia, adjoining Katanga on the south, huge deposits of copper ore have been discovered also, and exploitation has already begun The ores thus far worked in Katanga and Rhodesia have averaged nearly six per cent copper, or more than three times as rich as the average ore mined in the United States

Formerly the Katanga and Rhodesian output was handicapped by great distances and the high costs of land transportation These were in large measure overcome by the opening of the Benguella railroad in 1931, which provided an outlet to the west at much lower cost than was possible toward the south or east The overland mileage was reduced about 250 miles and the ocean distance about 2,600 miles, thus bringing the African mines nearly 3,000 miles closer to European markets These improved transportation facilities have placed the African mines in an advantageous competitive position with the great copper mining districts of North and South America Furthermore, the Katanga and Rhodesian ore bodies occur under favorable mining conditions; the ores are rich, labor is cheap, and water supplies are ample for all needs.

The capital interests involved in Africa are predominantly

British and Belgian; American interests are, however, quite well represented The ore reserves of Katanga and Rhodesia are so great that these districts, until recently ignored, must from now on be considered among the foremost areas of exploitation in producing the world's supply of copper. Furthermore, although American supremacy in the copper industry may not be overthrown, the percentage of the world's output contributed by the United States will undoubtedly be reduced.

Other important copper producing centers.—The widespread occurrence of copper ore is revealed by the fact that its mining is an industry of commercial significance in every continent except Antarctica In the western hemisphere, Canada, Mexico, Peru, and Cuba have important copper mining activities, although they are greatly overshadowed by the United States and Chile. In Europe, the mining of copper ore has been important for centuries in Spain, Germany, Yugoslavia, Scandinavia, and England. Russia also has an expanding industry with large potentialities for the near future In Asia, Japan is quite well supplied with reserves of copper ore, and she is expanding her output to meet the needs of her growing industrialism. Although weak in coal, petroleum, and iron, Japan finds considerable consolation in the availability of such resources in neighboring lands, and in her own dependable stores of copper ores.

ALUMINUM

Aluminum has been developed on a commercial basis in the last 25 years As late as 1890 it was referred to as a curiosity; the cost of extracting it from the ores was so great that it had practically no commercial importance. The price was then more than $2 a pound, while in recent years it has sold as low as 18 cents a pound. It is one of the most startling illustrations in the world of metals of an element which, though known for a long time, had not been considered of commercial value because of the difficulty of extracting it from its compounds.

Aluminum is one of the most abundant elements in the earth's crust, but it does not exist in a form which makes ex-

traction easy It occurs in clay, kaolin, feldspars, and other minerals, which are not yet commercial sources although scientists have been working for a number of years in attempting to devise means of extraction which would be commercially successful *Bauxite* is the principal ore of aluminum, and present indications are that it will remain so for a long time. Stated non-technically, bauxite is a compound wherein aluminum occurs in chemical composition with oxygen and water and is usually also associated with other elements occurring as im-

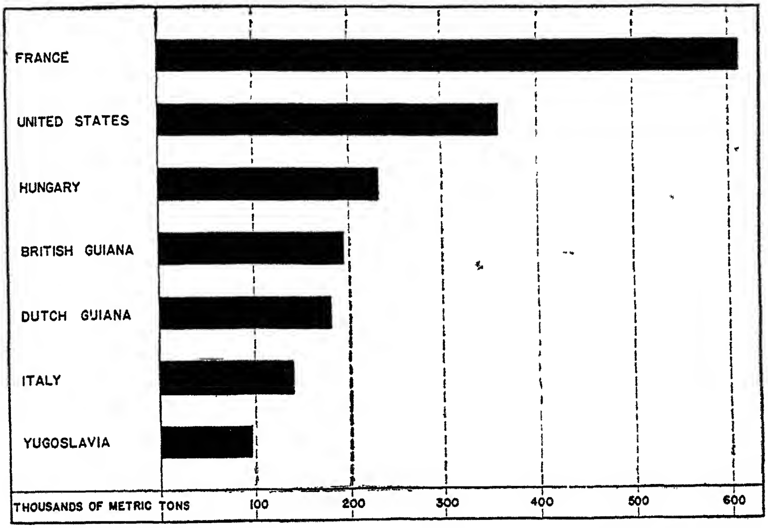


FIG. 148.—Bauxite output of the leading countries. Average 1926-1930. (Source of data *The Mineral Industry*, edited by G A Roush)

purities in the ore. Bauxite, if pure, would contain 39.13 per cent aluminum, but as mined it contains only about 30-35 per cent of the metal.

Bauxite is known to have wide occurrence in the world. France and the United States are the leading producers at the present time, but active exploitation is also in progress in British and Dutch Guiana as well as in Hungary, Italy, and Yugoslavia. The name was taken from the small town in southern France, Les Baux, where the ore was first discovered and commercially exploited. Valuable deposits are reputed to have

been discovered in Italy, Spain, and India, but commercial production is as yet on a small scale

In the United States, bauxite is known to occur in a number of places, the most important being in Saline County, Arkansas, where approximately 90 per cent of the total output of the country is mined It is also found in Alabama, northern Georgia, and near Keenburg and on the slopes of Missionary Ridge in Tennessee

Courtesy, Republic Mining and Manufacturing Company

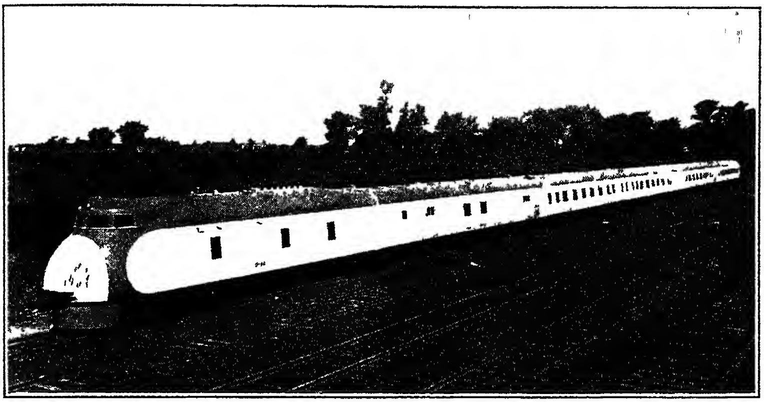
Fig 149.—Mining bauxite in Arkansas

Uses of aluminum.—The properties of aluminum giving it high industrial value are: (1) lightness; (2) resistance to atmospheric corrosion and to the action of a wide variety of chemicals, (3) ease of fabrication; (4) high thermal and electrical conductivity; (5) high reflectivity for light, ultraviolet, and thermal radiation.

The pure metal is comparatively soft and ductile, but when fused with other metals the resulting alloy may have qualities comparable with those of structural steel The elements com-

monly used in the commercial alloys of aluminum are copper, silicon, magnesium, manganese, zinc, and iron.

New uses for aluminum are continually being discovered, uses which carry it into the realms of architecture, furniture, machinery, and electrical equipment Among the most interesting developments in the use of aluminum are those associated with transportation, embracing all the principal branches on land, on sea, and in the air. Aluminum and its strong alloys have entered into the construction of railway equipment, freight containers, commercial truck bodies, ships, airplanes, and lighter-than-air craft. In recent years they have even



Courtesy, Union Pacific Railroad Company

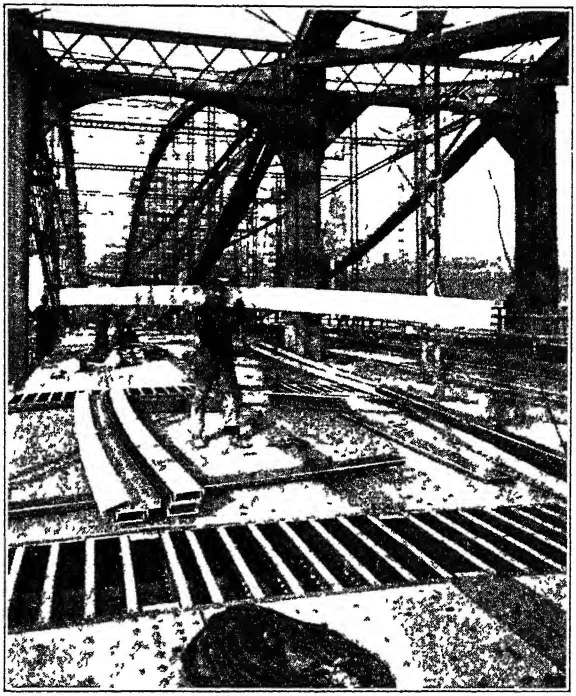
Fig. 150.—High speed motor train constructed of aluminum alloys, only trucks and wheels are made of steel.

entered the realm of heavy construction in the form of structural metals for bridges and large buildings

From the standpoint of quantity of aluminum used, the manufacture of cooking utensils and other household appliances ranks second to the manufacture of transportation equipment. Substantially reduced costs of manufacture have placed aluminum ware within reach of nearly all households and have opened up huge markets for such products. The electrical industry is third in importance. It has been expanding rapidly in late years because of the use of aluminum for electrical conductors for high-tension transmission lines, where aluminum steel-reinforced cables are standard construction.

From 40 to 70 per cent of the bauxite output is used as an ore for the extraction of aluminum. In addition, however, bauxite enters directly into the manufacture of abrasives and chemicals. In some years the abrasive and chemical industries use more than 60 per cent of the total output of this ore.

Conversion of bauxite into aluminum.—As mined, bauxite is bulky and of low value in proportion to weight; hence the



Courtesy, Aluminum Company of America

Fig. 151—Use of aluminum alloy in floor construction of a bridge at Pittsburgh The shape the workman is carrying weighs only 104 lbs. A similar steel shape would weigh nearly 300 lbs.

necessity of removing by chemical treatment most of the impurities and moisture before long and expensive freight haulage is undertaken Where the bauxite is so located that it can be reached only by rail, such processing occurs relatively near the mines. Where water haulage is possible the ore can be shipped long distances. In the United States, East St Louis,

Illinois, is the center for converting bauxite into *alumina* (aluminum oxide) The central location of this city enables treatment there of the ores from Arkansas without long railway haulage, and by water routes bauxite can be shipped there from the Guianas and some even from Europe Ocean steamers bring the ore to New Orleans, whence transshipment is made by river barges to East St Louis.

After chemical treatment and removal of impurities, the product, alumina, is much lighter and more valuable than the bauxite from which it was derived. Conversion into metallic aluminum involves removal of the chemically combined oxygen This necessitates reduction by electrolytic processes; and since heavy use of current is essential, the refineries are located where large waterpower plants developing cheap hydroelectricity are available. The most important reduction plants in North America are located at Niagara Falls and Massena, New York; Alcoa, Tennessee; Badin, North Carolina; and Arvida, Province of Quebec, Canada. The output of alumina from East St Louis furnishes most of the raw material used by the reduction plants in the United States Alumina is there reduced to refined metallic aluminum, which is then ready for manufacture into any shapes or forms desired.

It should be clear from the foregoing statements that bauxite is first treated chemically, thus producing alumina, much lighter and more valuable per ton than is the original ore. This treatment is performed in plants located near the ore deposits, or where cheap water haulage is available from mine to plant. The second step is electrolytic reduction of the alumina from the oxide to the metal, a process corresponding to the smelting of iron ore to pig iron This demands heavy use of electricity, and therefore the reduction plants are located where cheap power in large quantities is available The third step of manufacture is the shaping of the metal into the forms demanded by the trade, and such factories, scattered widely, obtain their bars of aluminum from the electrolytic reduction plants.

Foreign sources of bauxite and aluminum.—In the production of bauxite, France consistently holds first place, accounting

for over 30 per cent of the world's output The United States is second, and this position seems fairly well assured. The other principal sources are Hungary, Dutch Guiana, British Guiana, Italy, and Yugoslavia

It is significant, however, that a number of the leading bauxite producing countries are not important aluminum producers. This is caused by the fact that the ore moves to the great reduction centers, and these are not always located within the ore-producing countries. France, the leading producer of bauxite, ranks fourth in output of metallic aluminum and is practically on a par with Norway, Canada, and Switzerland, none of

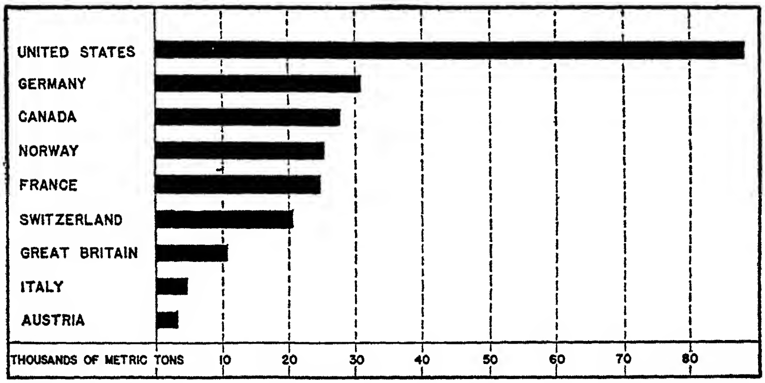


FIG. 152.—Aluminum production of principal aluminum producing countries. Average 1926-1930. (Source of data *The Mineral Industry,* edited by G. A Roush)

which are credited with any bauxite production whatever Germany, ranking second in output of aluminum, is not an important bauxite producer, although deposits of low grade ore are known to occur in several places. The United States is the only country which ranks high in output of both bauxite and metallic aluminum

Future outlook.—The large supplies of ore which are known to exist, the improvements in the methods of extraction, and the new uses being discovered for aluminum make the outlook for industrial expansion promising indeed At present the principal problems confronting the aluminum industry are

those of finding new uses for the products and of extending markets into fields that have not previously been covered. In this respect, the expansion of the aircraft industry and the demands for strength, speed, and lightness in transportation equipment on land and sea seem to assure rapidly expanding markets for aluminum products in the near future.

LEAD

The properties which make lead valuable are its malleability and its resistance to corrosion and to the action of some of the acids which are extensively used in industry. It can easily be rolled or hammered into sheets, but it lacks ductility—that is, it cannot be drawn out into fine thread or wire as can copper or iron. Its resistance to corrosion makes it exceptionally valuable as a conduit for cables, so widely used in the telephone and telegraph industries. Since lead is the only one of the common metals which is unaffected by sulphuric acid, it is used in the construction of linings of all kinds of apparatus used in connection with the manufacture of this important industrial chemical.

With the expansion of manufacturing, lead has become of great importance as an industrial metal. Since 1880 the uses of lead have been greatly extended in different fields, especially in the electrical industries, which now absorb 35-40 per cent of the total output of the United States. The construction and chemical industries use an additional 25-30 per cent. The growing importance of storage batteries for automobiles, and other kinds of electrical equipment, accounts for approximately 20 per cent of the total consumption, while another 5 per cent is used as lead foil in the manufacture of wrappers and containers for a number of commercial products These various uses give us an appreciation of the importance of lead for modern industry For many of them there are no satisfactory substitutes, and therefore the lead producing countries ordinarily find a ready world market for their output.

Geographic distribution of lead ores.—The most important lead ore is a chemical combination of lead and sulphur known

as *galena*, which, when pure, contains 86 4 per cent of metallic lead. It is readily recognized by its weight and its tendency to occur in regular cubic crystals.

Lead ore is widely distributed, and every continent seems to have some deposits of potential value The foremost production centers outside the United States are in Mexico, Canada, Germany, Spain, Australia, and Burma. Although lead ore is mined in at least eight European countries, Europe is able to furnish only about one-half of its own needs, the remainder being imported from the United States, Canada, Mexico, and

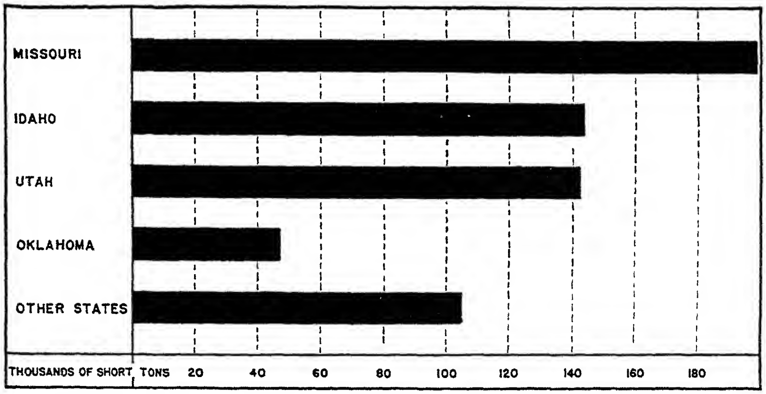


Fig. 153.—States leading in mine output of lead. Average 1926-1930. (Source of data *Mineral Resources of the United States*, Bureau of Mines, Washington, D C)

Australia The United States alone ordinarily furnishes 35 to 40 per cent of the total world supply.

Lead output of the United States.—In the United States the foremost lead producing center is in southeastern Missouri Considerable quantities of ore are produced also in the southwestern part of the state and in the adjacent areas of Oklahoma and Kansas Missouri's position as the foremost lead mining state is of long standing, and present indications point to continuance of that position for years to come Ranking next in importance are Idaho and Utah, followed by Oklahoma, New Mexico, and Kansas The total output of refined lead of the United States in late years has fluctuated from a high mark of

637,000 metric tons in 1929 down to 251,000 metric tons in 1932.

Lead output of foreign countries: *Mexico.*—The production of lead in Mexico has varied greatly during the past twenty years. Prior to 1913, under fairly stable government conditions, the country had attained fourth place, being surpassed by the United States, Spain, and Germany Because of unsettled conditions, production declined to a very low level in 1916. Since that time the general tendency has been upward, and Mexico has taken second place among the countries of the world, with an output exceeding 240,000 tons in some years. The lead industry of Mexico is financed in large measure by

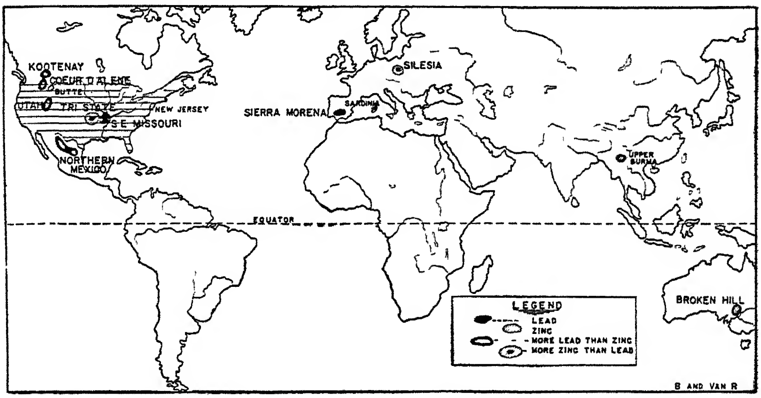


Fig. 154—Principal lead and zinc producing regions of the world.

American capital, and much of the foreign trade is carried on with the United States

Spain.—The lead mines of Spain have been operated for a long time, and costs are such that when world prices are low, production at a profit is impossible As a result the production of lead in Spain has shown a slow, downward trend. There is little prospect that the future will show any marked change from this general tendency, but the lead mining industry of Spain has shown remarkable stability during recent depression years, and therefore rapid decline is not expected. Spain will undoubtedly continue to rank high in its contributions to the lead supply of the world.

Germany—Germany has the distinct advantage of having an abundant supply of fuel for smelting and refining purposes, and thus she holds a highly favorable trade position in European markets Cheap fuel, nearness to centers of consumption, splendid transportation facilities, and efficient marketing organizations are advantageous factors Ore reserves, however, are not large, and the output of domestic mines is insufficient to meet the country's needs. Germany ranks third in lead consumption, and ordinarily must import about 50 to 65 per cent of the tonnage needed.

Canada.—The lead output of Canada has been increasing moderately during recent years. The greater part of the production is in British Columbia, that province accounting for approximately 93 per cent of the total output of the Dominion. Smaller quantities are produced in the provinces of Quebec and Ontario Canada has the advantage of large capital resources from the United States and Europe and of intimate commercial relations with the other parts of the British Empire Furthermore, cheap power is available in the mining area, a factor favorable to the mining and smelting operations. It is believed that large reserves exist, and if future exploratory work should prove this to be true, Canada will undoubtedly hold its place as one of the great lead producing countries

Australia—Australia has been an important lead producer for a number of years and has recently attained third place among the countries of the world There seems no question that ample ore reserves exist, the principal ones occurring in New South Wales and Queensland The large stores of ore which are known assure Australia a place of permanent importance, but it seems unlikely that any great development will take place in the near future, because of the difficulty of competing with the production centers located closer to the great industrial areas.

International trade.—On the whole the New World is the principal source of lead exports, and the Old World is the principal market Europe produces less than half of the lead that it needs, and therefore depends upon outside sources for supplies to make up the deficiency. Ordinarily the United King-

dom is the foremost foreign market for lead exports from the United States, followed closely by Germany, France, and Japan.

The uses of lead are so universal in the industrial world that no country can dispense with this metal, and therefore the present situation in foreign trade is not likely to undergo any radical change in the near future. It seems entirely probable that the European countries, together with Japan and perhaps China, will continue to be the great purchasing centers, whereas the United States, Mexico, Canada, and Australia will continue to be the great surplus producing countries for a number of years to come.

ZINC

The properties which make zinc particularly valuable are its resistance to weathering, its malleability, and the chemical properties which give it high place in the manufacture of numerous alloys and pigments In the United States, zinc is used principally for sheets and plates, for galvanizing, and in the manufacture of brass. Galvanizing is a process of covering sheet iron or steel with a thin coating of zinc; iron sheets so treated resist rust, and thus their life is greatly prolonged. Brass is an alloy of zinc and copper in various proportions, but ordinarily it consists of from 66 to 83 parts copper and 34 to 27 parts zinc Zinc enters largely into the manufacture of electric batteries and of imitation gold and so-called German silver. Furthermore, chemical compounds of zinc are used in the manufacture of paints and rubber tires, and also as preservatives of wood.

Geographic distribution of zinc ores.—Sphalerite is the most important zinc ore It is a chemical compound of zinc and sulphur which, when pure, contains about 67 per cent metallic zinc It is often associated with ores of other metals, especially lead, and many of the zinc producing districts of the world practically coincide with those which produce lead.

The three countries which lead in the production of metallic zinc are the United States, Belgium, and Germany. Although

zinc mining is scattered widely over the world, the largest part of the mine output is furnished by a comparatively small number of places, with the United States producing from 40 to 50 per cent of the total.

Zinc output of the United States.—The Tri-state District, embracing southwestern Missouri and the adjacent parts of Oklahoma and Kansas, is the principal center of zinc mining, producing over 40 per cent of the output of the entire country Joplin, Missouri, is often referred to as the "zinc capital of America." In the Rocky Mountains zinc is found in complex ores which often contain also lead, manganese, gold, and silver

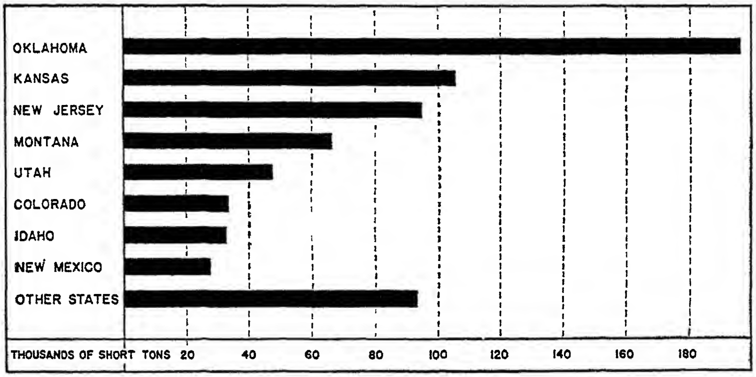


Fig. 155 —States leading in mine output of zinc. Average 1926-1930. (Source of data *Mineral Resources of the United States*, Bureau of Mines, Washington, D C)

Montana, Utah, Colorado, and Idaho usually produce about one-fourth of the nation's total. Zinc ores, almost free from lead, occur in New Jersey, the principal zinc mining state of eastern United States; but this district is an exception to the prevalent association of zinc ores with those of lead While production was formerly important in northwestern Illinois and southwestern Wisconsin, in recent years this area has declined into insignificance

The average annual production of metallic zinc in the United States is about 600,000 short tons. The Tri-state District, New Jersey, Montana, and Utah furnish somewhat more than 80 per cent of the ore.

Foreign production.—Zinc ore is mined in Poland, Germany, Italy, and various other countries of Europe The outstanding center is in Upper Silesia, a district in southeastern Germany and southwestern Poland Belgium is always credited with a large output of metallic zinc, but all of this is derived from imported ores and concentrates. The total output of zinc from the Belgian furnaces is approximately 15 per cent of the world's total Belgium is an example of a country well located as to markets, well supplied with fuel resources, and whose people have a high degree of mechanical skill, these factors have led to the development of a great refining industry which draws upon the ores from many countries for its raw materials In recent years Italy, Australia, and Mexico have furnished a major portion, but even the United States has contributed by furnishing concentrates to be refined and milled in the Belgian plants.

In Germany the principal zinc production occurs in Upper Silesia. The statistical position of the country was impaired when the smelting and refining plants were granted to Poland at the close of the World War Thus, the control of marketing the zinc passed out of the hands of the German producers In recent years, however, new smelters have been constructed in order to assure full control of all phases of the industry Germany was formerly not only self-supporting in zinc but produced a fairly large exportable surplus Since the loss of Upper Silesia, however, she has not been able to supply her own needs. Inasmuch as Germany has considerable reserves of ore, her increased smelter output of zinc may make her independent of foreign sources.

Poland.—During the past decade Poland has been credited with 7 per cent of the world's zinc production Large amounts of American capital have gone into the Polish works, and modernization of smelters has been undertaken with prospect of increasing their capacities and of bringing about greater economy of operation After the World War, Poland faced the handicap of having to take over smelters without having full control over the ore reserves necessary for their successful op-

eration. Furthermore, capital for keeping the plants in good shape and for introducing modern improvements was lacking. It is believed that with the assistance of foreign capital and skill, the zinc refining industry of Poland may attain high rank.

Other centers of zinc production —The principal zinc mining deposit of Australia is at Broken Hill, New South Wales Australia lacks the advantage of close contact with world markets, and hence it feels keenly the competition of the more readily available supplies of North America and Europe This remoteness and the lack of high grade fuels easily accessible to the mining industry are serious drawbacks to the development of the zinc ore resources of the country.

In recent years Canada has attained fifth or sixth place in zinc output among the nations of the world. While the extent of the ore resources is not well-known, it is believed that large reserves exist and that their exploitation will proceed vigorously when world markets justify the heavy investments necessary to put the industry on a large-scale basis

TIN

For many centuries tin was prized because when fused with copper it made bronze, a metal then greatly in demand Several centuries before the dawn of the Christian era tin was mined in the Cornwall district of southwestern England. The importance of this district, long the chief source of the world's tin, is indicated by the fact that careful students have estimated its total output from 500 B. C to 1800 A D at about 2,500,000 tons. Another important source of tin for many centuries has been the finger-shaped peninsula of southeastern Asia known as Malaya. It is estimated that more than a million tons of tin were obtained from this source before 1800 Until comparatively recent times, Cornwall and Malaya furnished nearly the entire tin supply of the world

Since 1800 the production of tin has been expanding at an increasing rate During the past 25 years about as much tin has been mined as during the entire preceding 100 years; this is a convincing index of its increased usefulness in the industrial arts of the world

Present uses of tin.—The uses of tin are based largely on its resistance to rust and decay It is affected but slightly by air or moisture, and it is so resistant to many acids, both organic and inorganic, that it enters extensively into the manufacture of tin plate for a wide variety of usages ranging from food containers to metal roofs. It is used also in the manufacture of solder, bronze, type metal, babbitt metal for bearings, and tinfoil for collapsible tubes

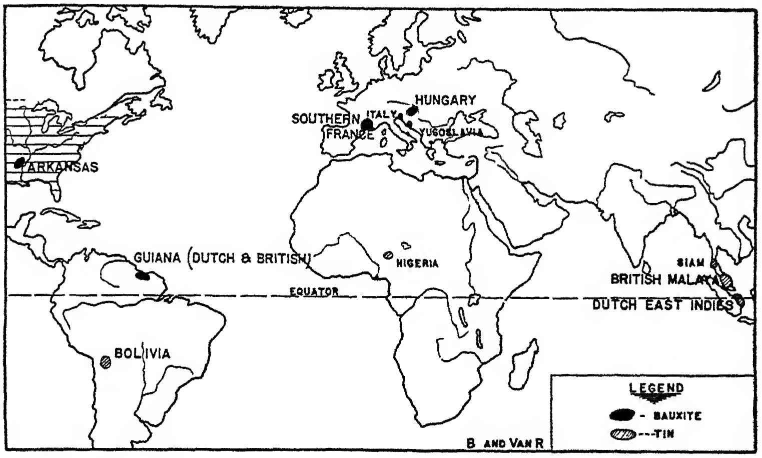


Fig. 156 —Principal bauxite and tin ore producing regions of the world.

The growing use of tin plate in the manufacture of so-called tin cans for preservation of foods has been an important factor in the growth of the tin industry since 1900. At first the method of preserving foodstuffs in tin cans won favor slowly because people thought that there was danger of poisoning through the corrosion of the metal. As a matter of fact, the spoiling which occurred was due to poor methods of canning and to the difficulties of properly sealing the cans, not to any fault of the tin. Another handicap was the cost of the cans. Until the invention of the stamp machine by Allen Taylor in 1847, the making of cans was a hand industry, and the best tin worker could make only about 60 cans a day This has been changed so that tin cans are now made rapidly and at amazingly low costs. With

machine methods of manufacture as well as of canning and sealing, and with increased knowledge of the limits of safety connected with this mode of food preservation, the entire tin industry has felt the spur of rapid progress.

Tin plate is made by coating steel sheets with pure tin, the practice being to use about one pound of tin in making 200 square feet of tin plate. Another important use is in the manufacture of *terneplate,* similar to tin plate, except that the coating consists of an alloy of lead and tin instead of pure tin. Terneplate is used for roofing, for gasoline tanks for automo-

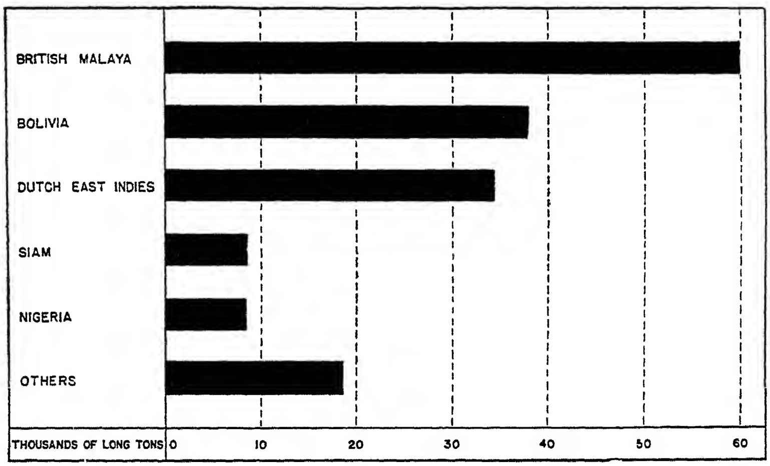
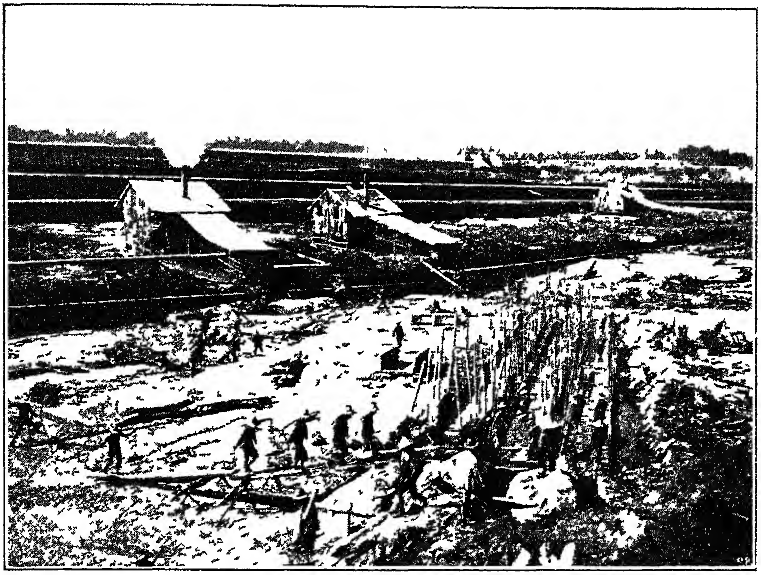


Fig. 157.—Tin production of principal producing countries. Average 1926–1930. (Source of data *Mineral Resources of the United States,* Bureau of Mines, Washington, D C)

biles, and for other non-food containers In the United States the manufacture of the two products, tin plate and terneplate, accounts for 35 to 40 per cent of the virgin tin consumed annually

The world's sources of tin.—Tin is a comparatively rare metal, a fact which many overlook because of the cheapness of tin plate and the resulting extensive use of "tin" cans The annual world output of tin varies from 150 thousand to 190 thousand metric tons, a small quantity in comparison with that of zinc and lead each of which ordinarily exceeds one and one-

half million tons. The bulk of the world's supply is furnished by the mines of three centers; namely, the Malay States, Netherland India, and Bolivia. A few other areas produce tin in sizeable quantities and have prospects of increasing their output in the near future; this is particularly true of Siam, Nigeria, and China, where fairly large bodies of tin ore are known to exist but exploitation has not yet been pushed vigorously. Cornwall, the ancient world center, now produces less than one per cent of the world total, and there seems little



Courtesy, Department of Agriculture, Industry, and Commerce of the Dutch East Indies Photograph by Banka Tinwinning

Fig. 158.—Open pit tin mining and sluicing near Muntok, Banka. This method involves much hand labor. Much of the present mining is carried on by means of large electric dredging machines.

probability of any improvement in its position. The United States is almost lacking in tin and is dependent entirely upon foreign sources for its surplus.

Most of the ore mined in Malaya and Netherland India is reduced to metallic form in smelters located in Singapore and on the island of Banka, whereas the ores mined in Bolivia and in Nigeria are merely concentrated near the mines and are

then shipped to smelters at Liverpool and at Redruth, Cornwall, England, to be converted into refined tin. Through ownership and operation of the smelters, the production of primary tin is controlled almost entirely by British and Dutch capital interests.

Outlook for the future.—Prospecting during the past two decades has indicated possibilities of important tin ore bodies in Africa, Russia, Japan, and Argentina That further exploratory work will be pushed vigorously whenever market conditions warrant, seems assured, and of course valuable ore reserves may be found. But for many years to come British Malaya will probably remain the foremost source of primary tin, and the efficient mining and smelting operations in Bolivia and Netherland India give promise of retaining those centers as the other members of the "Big Three" in the world's tin industry. There does not now appear any probability of change of leadership, either in centers of output or in capital control, for some time to come.

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CHAPTER XV

The Climates of the World

"EVERYONE talks about the weather but nobody does anything about it." This oft-quoted statement by Mark Twain concisely expresses the interest which most of us have in the daily weather. This widespread interest, so general as to be taken for granted, is obviously due to the sudden changes which are characteristic of the weather in the middle latitudes. But our interest often is more profound than is indicated by the trifling remarks we make concerning the weather conditions of today and tomorrow. When planning visits to other states or countries, or if contemplating a change of residence, we are apt first to inquire how cold the winters are and how warm the summers, whether it rains much or little, whether sunshine or cloudiness prevails. In other words, we seek to inform ourselves concerning the climate of our new place of abode.

Weather and climate.—Whereas *weather* refers to the actual atmospheric conditions which prevail at any given time, *climate* is ordinarily defined as the average of known weather conditions. Thus the climate of a locality can be described accurately only if long-time records of its elements—namely, temperature, rainfall, humidity, sunshine, and winds—are available. Such records are especially necessary in the middle latitudes, where not only the changes in the weather from day to day may be great, but where there is also considerable variation from year to year—mild winters and severe winters, hot summers and cool summers occurring in irregular alternation and succession. In such regions, climate, as the average weather, often seems at first sight to be a rather illusory conception.

There are, however, large parts of the world where atmospheric conditions are not so changeable, and where the principal characteristics of the daily weather may be foretold quite accurately by reference to the calendar It may be either always warm or always cold, always rainy or always dry, or wet and dry seasons may alternate with almost perfect regularity. Such uniformity of daily weather is especially characteristic of the lower latitudes Under these conditions the weather is not the absorbing topic of conversation that it is with us, and there records covering only a few years may suffice to give a fairly accurate idea of the climate

The importance of climate.—It is generally conceded that climate is directly connected with the health, happiness, and well-being of man Some climatic conditions are energizing, while others are enervating. Climate not only affects the health of man, but it also greatly influences his activities, since it virtually determines where each of the many kinds of plants and animals may thrive. In order to comprehend the economic life of people in other parts of the world, one should know the climatic conditions under which they make their living We can often more fully understand backward conditions if we take into account the climatic handicaps against which certain peoples have to struggle We can always understand better what goods people produce and what they need to buy if we have knowledge of the climatic conditions under which they live.

Climate and agriculture.—Agricultural production responds directly to climatic factors such as temperature, rainfall, sunshine, and wind, and thus the crops which can be grown in any particular area depend largely upon the type of climate which prevails there Where the climate is favorable, potential agricultural production may be high; where unfavorable, productivity may be so low that agriculture is impossible unless the climatic handicap can be overcome by artificial means as, for instance, overcoming aridity by irrigation The economic significance of this close relationship between climate and agricultural production is emphasized by the fact that, notwith-

standing the great development of modern industries, agriculture is still the most important means of making a living among the two billion inhabitants of the globe

The intimate relationship between climate and food, shelter, and clothing is generally recognized, and illustrations of this relationship can be found everywhere In cold lands the houses generally are sturdily built with thick walls, solid foundations, and elaborate heating systems, whereas in warm lands such features are ordinarily wanting The dwellers of cold lands clothe themselves in hides, furs and woolens, while those of warm lands wear clothes that are light and airy. People in the arctic regions consume great quantities of fats and do so with evident relish, whereas those in the tropics live on much lighter diets, placing greater dependence upon fruits and vegetables

Climatic dissimilarity as a fundamental basis of trade.—The significance of climatic differences goes beyond differences in food, clothing, and shelter, however important and interesting these may be That the people of the tropical lowlands grow and eat bananas and coconuts in abundance may interest us, and we may even feel envious at times over their good fortune in this regard, but the real economic significance of these facts is that through surplus production and efficient transportation, bananas and coconuts have become available in regions where they cannot be produced, *and thus they have become commodities of world commerce* The same holds true for a great number of other agricultural products. Throughout the industrial world we draw upon areas near and far for supplies to be used as food and as raw materials for manufactures. Not a day passes but that we are beneficiaries of the products of foreign lands, and daily our goods are shipped abroad to serve the needs of other peoples

Differences in climatic conditions are fundamental causes of differences in production, which in turn give rise to varying needs and desires. Therein lies the basis of trade, both intranational and international. For example, the farmers of Iowa produce a surplus of agricultural products, the sale of which

enables them to purchase manufactured goods from the east and citrus fruits from Florida and California. The United States produces a surplus of wheat and furs, and imports products of more southern climes; the people of Central America are enabled to buy the products of the north if they can sell their surplus of bananas, coffee, and coconuts. Thus, in large measure the currents of trade flow in response to climatic differences. If we desire to comprehend the fundamental basis of trade, we should not neglect to study the climatic factors involved.

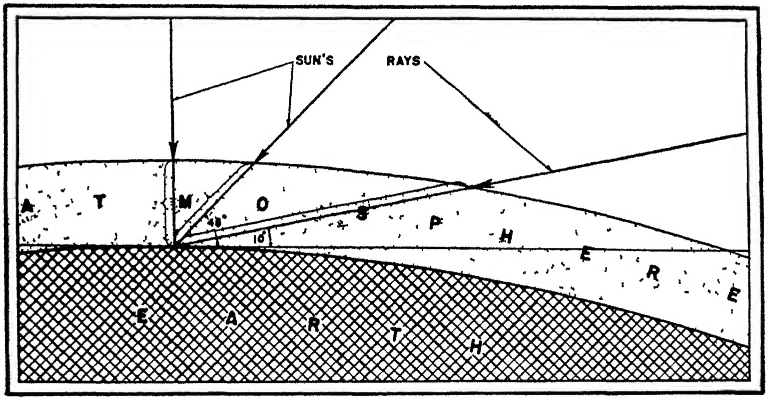

Fig. 159.—Diagrammatic illustration of differences in lengths of paths traversed by sun's rays through the atmosphere at different positions of the sun in the heavens.

The elements of climate: *1. Temperature.*—Temperature is the term used to express the intensity or degree of heat. Heat is radiated into space by the sun, and although the earth intercepts but a very small fraction of the total, this fraction is the source of practically all the heat energy available upon the earth. The heating of the earth through direct radiation from the sun is known as *insolation*. The more nearly perpendicular the sun's rays strike the earth's surface, the greater is the insolation, because the heat is concentrated upon a relatively small area and there is a minimum loss from passing directly through the atmosphere Slanting rays, on the other hand, are spread over a larger area and lose more of their heat when

passing through the atmosphere diagonally, and thus are less effective in heating the earth. Hence, in the middle latitudes insolation reaches a seasonal maximum during the summer At the equator the sun is near the zenith most of the year and actually in the zenith at the times of the equinoxes. Insolation there is great the year through, the maxima occurring in March and September.

Unequal heating of land and water.—The effects of the sun's rays on land and water are not the same. Equal insolation results in less rise in temperature of water than of land. This is due to three major factors: (1) the relatively high specific heat of water—that is, more calories of heat are necessary to raise the temperature of water than of land one degree; (2) the sun's rays penetrate water to a much greater depth than they do land, and thus the intensity of heating at the surface is less; and (3) the mobility of water permits transference of heat to colder layers or places by means of waves and currents.

As a result of all these factors, water bodies remain at much steadier temperatures than do land areas. During the summer, in the middle latitudes the land is much warmer than the ocean; in the winter time it is much colder. This difference is of great importance, especially in the winter. In this season, extensive water bodies give off large amounts of heat which moderate the winter temperatures of nearby land masses.

Influence of altitude.—Differences in altitude also lead to differences in temperature. At the higher altitudes insolation results in less heating because of the greater loss of heat by radiation through the rarified atmosphere Thus, mountain and plateau regions always have lower average temperatures than do neighboring lowland areas.

World distribution of heat.—An isothermal map of the world based upon actual average annual temperatures clearly shows the disturbing effects of the factors mentioned above. The isotherms do not follow the parallels around the globe, as one might expect; they diverge northward and southward. The irregular courses of the isotherms are due primarily to the unequal distribution of land and water and the resulting un-

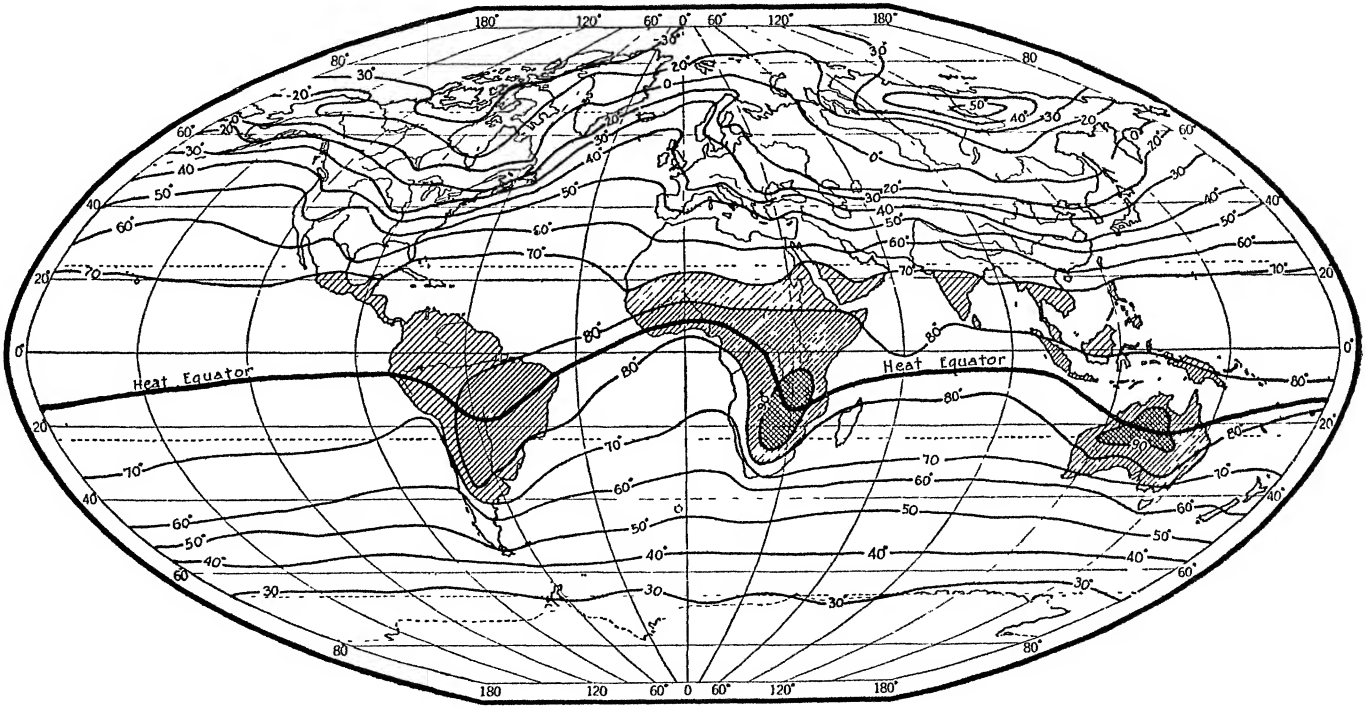

Fig. 160.—Isothermal lines for January. (From Huntington and Carlson *The Geographic Basis of Society*, New York, 1933. Prepared by F A Carlson)

equal heating Among other factors should be mentioned (1) the occurrence of highland areas, (2) the transference of equatorial heat poleward and of polar cold equatorward by means of ocean currents; and (3) the transference of warm and cold air by prevailing winds.

Temperature as a factor in climate.—The changeable temperatures of the United States and Europe furnish an inexhaustible subject of conversation because of their direct relationship to our pursuits and pleasures But more than that is involved. Changeableness of temperature, and of weather conditions in general, has been recognized as a valuable energizing influence. The world's work has long been done most effectively by people who live where days vary from warm to cold, from dry to rainy, and from calm to stormy. Man's physical and mental energy seems to respond to the stimulus of change

The enervating effect of the monotonously warm and humid weather of the lower latitudes is well known. There hustling white men from cooler climes gradually and almost inevitably become slow-moving and lazy, since the climate is not conducive to such activity as is commonly found in the middle latitudes

In the high latitudes, conditions of an entirely different kind are encountered There nature is so harsh that man is almost defeated by the continuous low temperatures, the severe storms, and the low productivity of the land Agriculture and industry must leave the field to hunting and fishing.

Progress is the result of the wise use of leisure Where there is too much leisure it is commonly not appreciated and therefore is not used wisely. The all-year warm and humid regions provide conditions where man can live with little effort if mere existence is all he cares for Too much indolence induced by climate, with too much leisure as a result, seems to rob the people of the incentive to progress In the polar areas, opposite conditions prevail Man's energy is used up in fighting for the bare necessities of life, and hence there is no surplus energy whereby any available leisure might be turned

to profit. Under such circumstances progress must necessarily be slow

Most of the great inventions by which the productive capacity per individual has been increased and most of the great advances made in the realms of literature, music, drama, and art are testimonials of man's achievement within the belts of intermediate climates. Since warm climates are enervating, and cold climates are too harsh, the intermediate ones present the happy medium between the less desirable extremes. There man must work to live and the rewards are such that surplus production is possible. Leisure can be made available, though not too cheaply, and the stimuli of changing weather are conducive to physical vigor and mental alertness. Such a combination spells progress.

The elements of climate: *2. Air pressure and winds.*—The atmospheric air, obeying the laws of gases, exerts pressure in all directions, the amount of pressure varying with the density of the air At sea level, where the air is weighted down by all the air above it, density is greatest, and the pressure amounts to 14.7 pounds per square inch. At greater altitudes, where the air is less weighted down and therefore not so dense, the pressure is less. Air pressure is measured by means of the barometer. At sea level the normal atmospheric pressure is indicated by a barometric reading of 30 inches, or 760 millimeters. With increase in altitude the height of the column of mercury that the air pressure can sustain decreases in the beginning at the rate of about one-eighth of an inch per 100 feet. The rate decreases at higher altitudes. The following table illustrates more accurately the rate of change

RELATION OF AIR PRESSURE TO ALTITUDE

Altitude	*Barometer*
0 feet	30 inches
910 feet	29 inches
1950 feet	28 inches
2820 feet	27 inches
3800 feet	26 inches
4800 feet	25 inches
5900 feet	24 inches

When air is at rest relative to surrounding objects, we are scarcely aware of its presence; but when it is in motion, we readily recognize it because of the pressure or force which it exerts Air in horizontal motion near the earth's surface is called *wind* The atmosphere as a whole would be relatively calm if it were not for the unequal distribution of insolation over the earth's surface This unequal heating gives rise to air currents, the passage of which causes the phenomenon of wind. The winds are named as to the direction from which they blow; thus if air moves from the north toward the south, it is spoken of as a north wind. The direction from which the winds blow with greatest frequency is called the direction of prevailing winds; this varies in different places The velocity of the wind is the rapidity with which the air moves past some fixed point, and it is usually stated in miles per hour or in feet per second. Wind velocity is measured by an instrument called an *anemometer*.

Seasonal changes in wind directions.—Warm air is less dense than cold air; hence, areas of warm air are usually characterized by lower pressures than are areas of cool air. Since in the northern middle latitudes the continents are relatively warm in summer and cold in winter, the pressures generally are lower in summer and higher in winter than they are over the oceans in the same latitudes. Over the continents the air becomes heated in the summer, causing it to flow upward and outward toward the oceans. The loss of air through outward drift at higher altitudes causes the pressure of the atmosphere upon the lands of the interior to be less than the atmospheric pressure upon the adjacent oceans. Thus, in the summer the interiors of Eurasia and North America are areas of low pressure while higher pressures are characteristic of the bordering oceans, and therefore winds blow from the oceans toward the continental interiors. During the period of intense heating in summer, these winds from ocean to land are well developed; as autumn advances the movement slows down until a relative equilibrium is attained. Then as winter sets in and the air above the land is chilled more rapidly than the air above

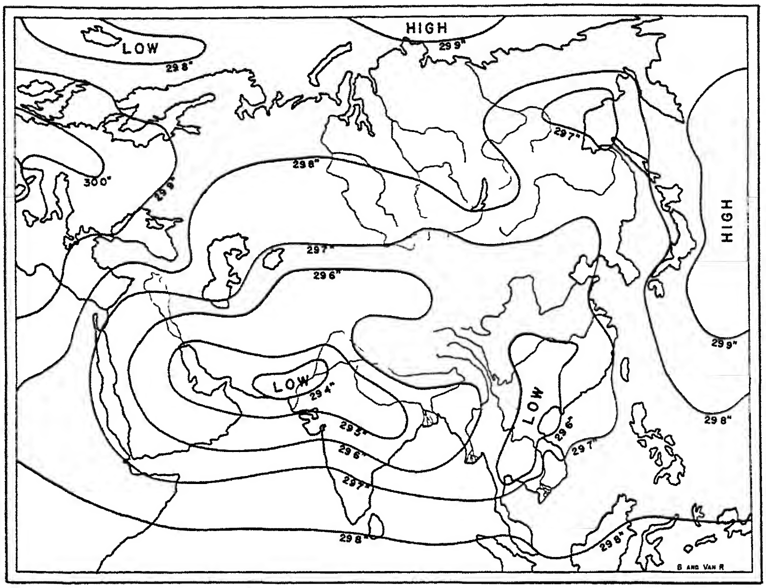

Fig. 161.—Atmospheric pressure in Asia in July.

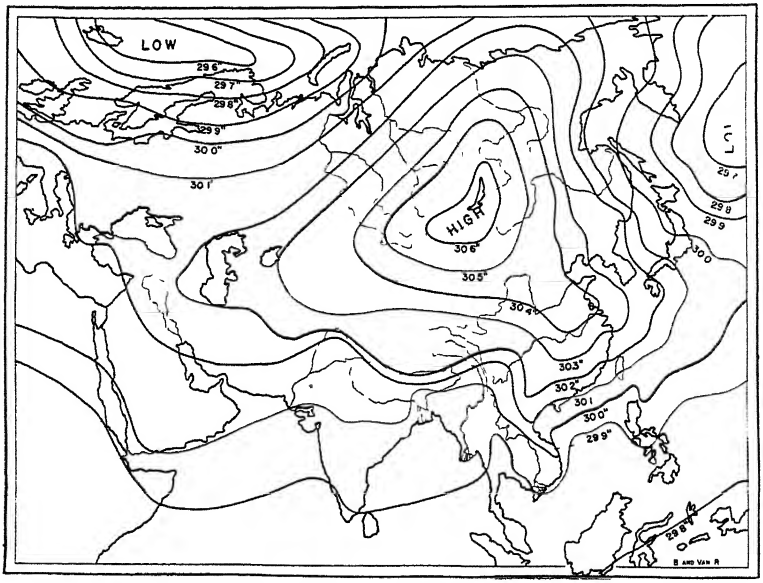

Fig. 162.—Atmospheric pressure in Asia in January.

winds which are caused by the decrease in annual insolation from the Equator toward the Poles, and by the rotation of the earth from west to east. Since the annual insolation is greatest near the equator, a belt of relatively low pressure encircles the earth there; this belt is known as the equatorial belt of low pressure calms, or the *doldrums*. The term doldrums is applied most generally to the equatorial calms over the oceans, but

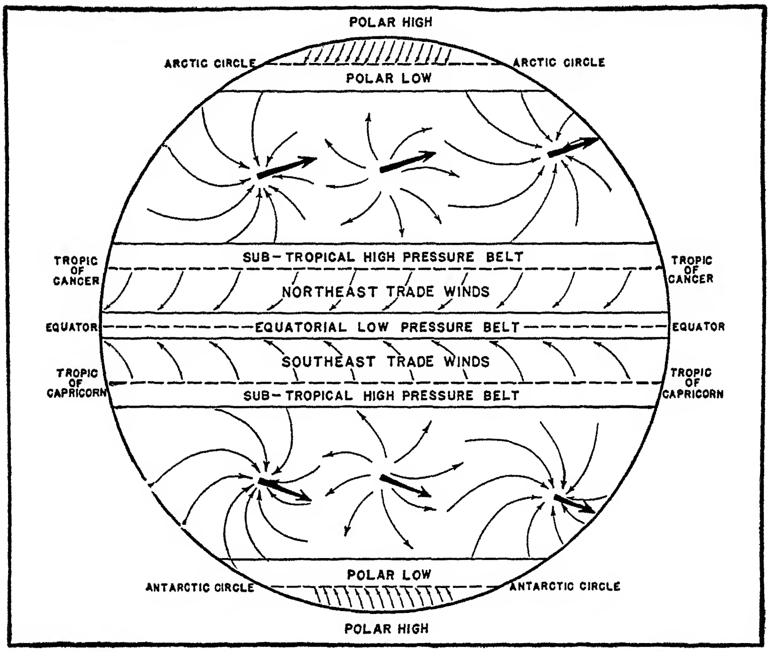

Fig. 164.—Diagram of the wind belts of the world.

lack of any better term seems to make it applicable to the corresponding belt of calms and variable winds over the lands as well. There, due to the persistent heating, ascending air movements are prevalent. As the air rises it expands and cools, finally reaching the dewpoint, with resultant clouds and precipitation. Thus, the doldrums are characterized by light, baffling breezes, interspersed with prolonged calms, by cumulus or so-called "thunder head" clouds, frequent thunderstorms, and heavy rains.

On the poleward sides of the tropics lie two belts where the atmospheric pressure quite constantly remains relatively high all year through. These are the so-called *subtropical highs* (horse latitudes), which are most persistent over the oceans. In these regions, as in the doldrums, calms are frequent. Since

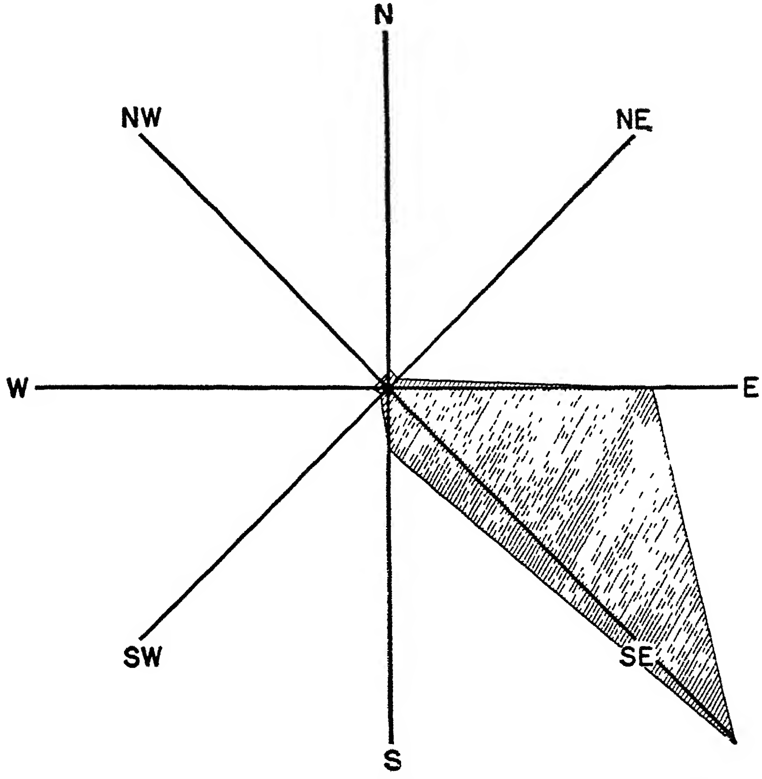

Fig. 165.—Wind rose characteristic of the Trade Winds. Fernando Noroñha Island, northeast of Recife, Brazil, 1911-1912.

descending air currents rather than ascending ones prevail, the sky is nearly always clear and the amount of moisture in the air is small. The subtropical high pressure belts over the earth are thus characterized by aridity; they are veritable desert belts.

Along the surface—i.e., to altitudes from 10,000 to 30,000 feet—winds blow from the subtropical high pressure belts

toward the equatorial belt of low pressure These winds, blowing from the northeast in the northern hemisphere and from the southeast in the southern, are called *trade winds* Their velocities vary from moderate to brisk and their direction, particularly over the oceans, may remain unchanged for weeks at a time.

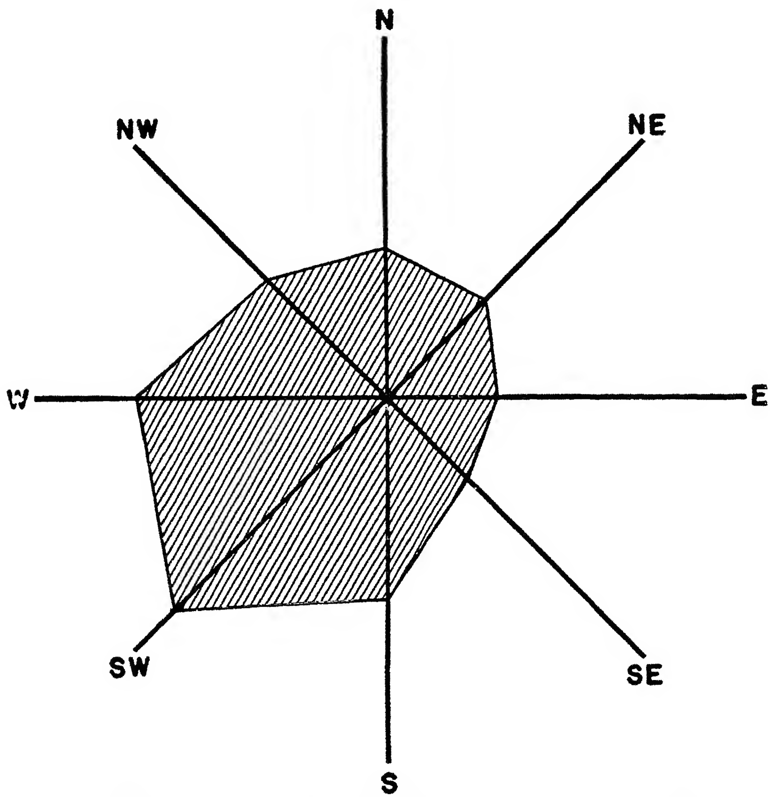

Fig. 166 —Wind rose characteristic of the Westerlies Stornoway, Hebrides Islands, 1876-1916.

Poleward, beyond the subtropical highs, the general atmospheric drift is from a westerly direction; but the surface winds, especially in the northern middle latitudes, are highly variable in direction and velocity, and they are characterized by irregular, whirl-like movements toward the centers of low and away from the centers of high pressure These great whirls are called

cyclones and *anticyclones,* respectively. Their height varies between two and six miles, and they have diameters of from 500 to 1,000 miles. The belts in which they govern the weather extend roughly from latitudes 30° N & S to latitudes 60° N & S, and are known as the belts of the *prevailing westerlies.* The drift from west to east is steadier in the southern hemisphere than in the northern, and the wind velocities are greater, often reaching gale strength For this reason, particularly among sailors, these winds are spoken of as the "brave west winds," or the "roaring forties."

Near the Arctic and Antarctic circles there are belts with lower pressure than prevail either equatorward or poleward. These subpolar low pressure belts appear to attract many of the great cyclonic whirls of the prevailing westerlies Prominent centers of low pressure within this belt of the Northern Hemisphere lie near the Aleutian Isles and near Iceland; these are commonly referred to as the "Aleutian Low" and the "Icelandic Low" respectively

Around the poles the atmospheric pressure seems to be permanently high These polar highs give rise to easterly winds which blow toward the subpolar low pressure belts

The elements of climate: *3 Rainfall.*—It has already been pointed out that dewpoint is the temperature at which air is saturated with moisture (Page 73). Since the capacity of any given volume of air for retaining water vapor is largely dependent upon its temperature, when warm air is cooled, its capacity for holding its moisture content is reduced. When dewpoint is reached the surplus begins to condense. In the atmosphere the surplus takes on the form of clouds, fog, rain, snow, hail, dew, or frost, depending upon the conditions under which condensation takes place.

Clouds consist usually of fine droplets of water, and sometimes of very small ice crystals. The droplets tend to fall to earth, but are often kept floating by upward or transverse air currents. When these droplets grow in size, rain may eventually result.

The cooling of the air, necessary to cause condensation of

water vapor, may be produced in three ways: (a) adiabatic cooling—that is, cooling by expansion as the moist air rises or is forced to rise; (b) mixing of warm and cold air masses; and (c) cooling by contact with cold surfaces. Of these three, adiabatic cooling is responsible for most of the precipitation of the world. It may be brought about (1) by convectional currents which may give rise to convectional rains, (2) by winds ascending mountain slopes and thus producing orographic rains; (3) by cold air masses wedging underneath masses of moist, warm air and forcing them upward, or by warm, moist air being forced to override masses of cooler, heavier air, in either case producing cyclonic rain. The heavy rains characteristic of the equatorial belt and the summer thunderstorm showers of the middle latitudes are usually of the convectional type. Mixing of masses of warm and cold air may give rise to the formation of light clouds, but it usually results in little precipitation. Contact with cold surfaces generally causes condensation, as dew or frost, but rarely produces rain.

The amount of rainfall is measured in inches or millimeters. The rain water may be caught in any open, vertical-walled vessel and its depth measured directly The standard rain gauge, however, is a cylinder which drains through a funnel into a lower-placed cylinder with a cross-section area one-tenth as large as the upper one. Thus the lower cylinder registers one inch for each one-tenth inch of rainfall In this manner readings of greater accuracy are obtainable than through direct readings in the larger open vessel.

Relationship of rainfall to wind belts.—The interrelationships between the type and amount of rainfall and the wind belts of the earth are so close that one needs to keep in mind the average position of these belts and their seasonal migrations in order to understand the distribution of rainfall over the earth. The total amount of precipitation during the year is, on the average, greatest near the equator The equatorial belt of low pressure has the heaviest rainfall, the convectional type prevailing. In the subtropical highs and the trade wind belts precipitation is scant, since the air is moving either downward

or equatorward, and thus is warmed rather than cooled. However, the rainfall is quite heavy wherever mountain slopes force the trade winds to rise—as, for example, along the coast of southeastern Brazil and along the northeast coasts of the mountainous islands of the West Indies.

In the belts of the prevailing westerlies, precipitation is moderate and tends to be greatest along the western, windward margins of the continents. Where the mountain ranges rise immediately back of these west coasts, as in British Columbia

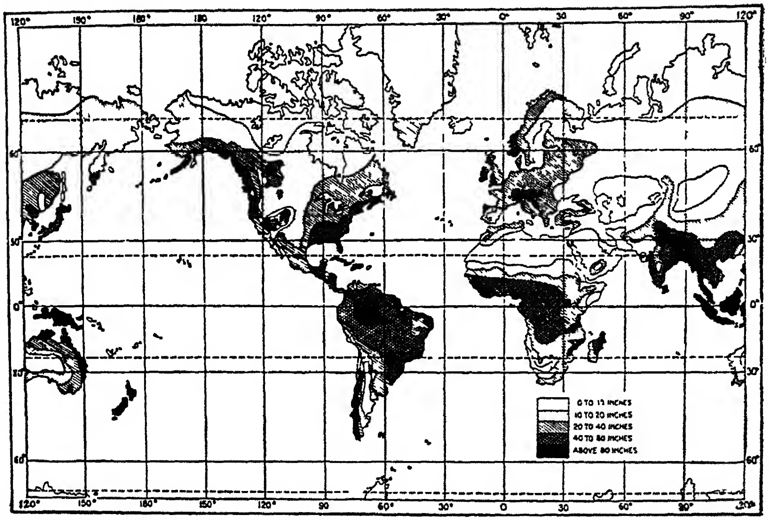

Fig. 167.—Average annual rainfall.

and western United States, the precipitation on the exposed slopes is heavy, whereas the eastern slopes are quite dry. This contrast is especially marked in the winter season when the inblowing winds are rapidly cooled as they move over the cold mountain slopes. Therefore, where there are no high bordering ranges, as in western Europe, the moisture is carried farther inland and precipitation is not so heavy near the coast. In the belts of the westerlies even the east coasts are fairly well watered, because of the moist air carried inland from the oceans by the east and southeast winds which accompany the passage of the cyclonic storms so characteristic of these wind belts.

Rainfall a principal factor in climate.—One of the most vital respects in which climates differ is that of rainfall. Water is the great solvent by means of which plant and animal foods can be converted into tissues and into active energy Thus, where rainfall is scanty the possibilities for all sorts of organic life are less than where rainfall is abundant. Vast areas of the land surface have little capacity for production because of insufficient rainfall In these desert or semi-desert regions, vegetation is scattered and is specialized along the all-important phase of conserving every drop of water Leaves are small, often wanting, in which case the stems perform the function of the leaves Cacti and thorny bush are characteristic examples of arid land vegetation. Food plants are scarce, and but little grain can be produced Under such conditions, agriculture must be chiefly of the herdsman type. Fixed habitations are not possible; in order to live, animals and man must be able to move swiftly from place to place It is the land of the fleet and the wary, the gazelle and the nomad. If fleetness is lacking, defense must be relied upon, and horny plates and poison fangs come into play The horned toad and the Gila monster are forms of adaptation to the land of little water

Abundant rainfall coupled with high temperatures is conducive to heavy vegetation The Congo basin of Africa and the Upper Amazon Valley of Brazil are drenched with rain and covered with dense jungle. In both areas, however, vegetation is so luxuriant that it seems to smother both animal and human life. A superabundance of precipitation may be a handicap almost as severe as too little rainfall

Rainfall and distribution of population.—On the basis of precipitation the climates of the world may be classified into humid and dry Such a classification must necessarily be somewhat arbitrary When we travel from humid to arid regions we can not find any definite line dividing the two, yet for practical purposes, limits must be chosen and lines drawn Thus, areas having an average of less than 20 inches of rainfall per year are classified as dry—that is, as semi-arid or as desert lands—whereas areas having an average annual rainfall of more than 20 inches are classified as humid.

Comparison of rainfall and population maps shows that on the whole the extensive dry lands of the world are but sparsely peopled and that the bulk of the world's population lives where moderate rainfall prevails. Where there is little rain, dearth of foodstuffs is the limiting factor; where rains are too abundant, man is overcome by vegetation and disease In general, the areas of density of population have an average rainfall of less than 60 but more than 20 inches per year.

General characteristics of climates.—The climatic elements, such as temperature, humidity, rainfall, and winds, attain average annual or average seasonal values which vary greatly from region to region Many combinations are possible with the result that there exist many different types of climate in the world. Many of these climates, however, have certain traits in common, depending on whether the influence of large water bodies or of large land masses is paramount in determining some of their outstanding characteristics

Marine or *oceanic* climates are characterized by small seasonal and daily temperature ranges Summers are cool and winters are mild Both the winter minimum and the summer maximum temperatures are usually delayed, February being the coldest month and August the warmest month of the year High humidity and prevailing cloudiness are two of the most typical characteristics of marine climates Rainfall is ample and well distributed throughout the year, but with a distinct maximum in the late fall The marine type of climate is, of course, best developed on islands and on exposed portions of coasts, especially on the west coasts of continents in the middle latitudes—as, for example, on the islands of Jersey and Guernsey off the coast of France, or on the peninsula of Cornwall, England.

The *continental* climates of the middle latitudes have great extremes of temperature, high temperatures being common during the summer and the daytime, and low temperatures in winter and at night. The temperature range generally increases, but precipitation decreases with the distance from the ocean. There is much less cloudiness in the continental climates than in those of marine type, and the prevailing humidity is lower.

The interiors of North America and Asia offer the best examples of well-developed continental climates.

Great altitude imparts a certain similarity to climates of widely separated regions *Mountain* climates are characterized by low air pressures and low temperatures. At high alti-

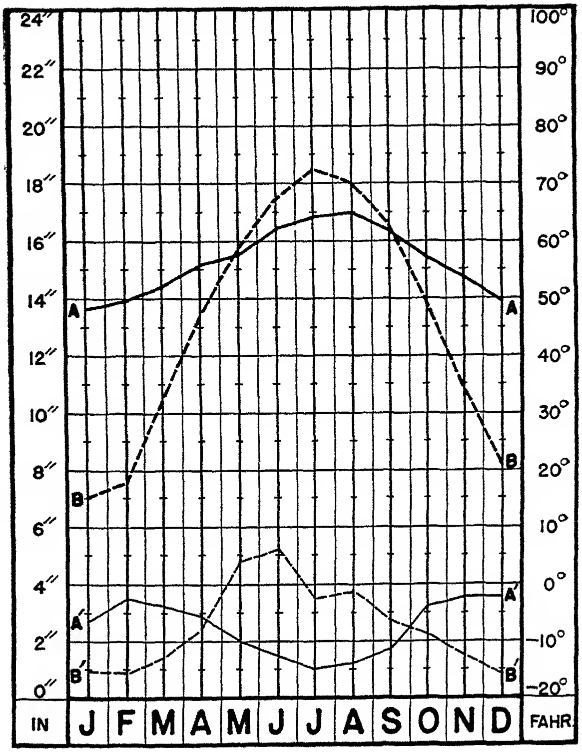

FIG. 168.—Comparison of oceanic and continental climates. Oceanic. La Coruña, Spain, temperature A, rainfall A′. Continental: Mason City, Iowa, temperature B, rainfall B′.

tudes insolation is intense, since the sun's rays have lost but little energy in their course through the thin and dry upper air. Nevertheless, the air in the mountains remains cool because radiation is rapid owing to the small amount of water vapor and carbon dioxide in the air at great elevations The light of the sun contains more ultra-violet rays than at sea

level; this, combined with the low barometric pressure and cleanliness of the air, is responsible for the establishment of sanatoria in many high mountain regions

Significance of type of climate and of climatic region.—An overview of the climates of the world should make clear the diversity of existing conditions, a diversity quite apparent even when viewed broadly The climates of tropical regions are warm, while those of high latitudes and of mountain heights are cold; between them are intermediate belts of changeable weather, where there is no monotony of either heat or cold Precipitation ranges from an average of nearly 40 feet per year to almost zero. In some years Cherrapunji, India, receives more than 600 inches of rainfall, while at the same time the desert of Atacama in South America is rainless.

Thus, the climates of the world range from all-year warm to all-year cold and from excessively rainy to desert. Classifications and descriptions of climates must be based on these fundamental facts and conditions through all their various phases. A *type of climate* must therefore have some outstanding characteristics of temperature and rainfall as to both quantity and seasonal distribution Associated with these are other factors of importance, such as winds, humidity, sunshine, cloudiness, and length of growing season. A *climatic region* is an area of land wherein the major dominant climatic factors have a high degree of uniformity, although some of the minor ones may show considerable diversity

The climatic region may be classified as geographic, because plant and animal life must become adapted to the prevailing conditions in order to survive, and human activities likewise are definitely related to the climatic environment. Similarity of climatic conditions often leads to similarity of industrial pursuits. It is equally true that pronounced differences in climatic conditions often lead to industrial dissimilarities Palms and spruces do not grow in the same climatic habitats; men do not raise bananas and wheat in the same climatic region.

A scheme of classification of the climates of the world.—As previously pointed out, the amount of rainfall is a factor

which is fundamental in causing climatic similarity or dissimilarity. Where rainfall is sufficient to promote tree growth, the climate may be referred to as humid; where insufficient to promote the growth of trees, it is said to be dry, a term which, as ordinarily used, covers both arid and semi-arid conditions Nevertheless, the type of vegetation is not the result of the amount of rainfall alone, since the effectiveness of a given quantity of rain is strongly influenced by other factors, both climatic and physical. Less rainfall is necessary to support tree growth in the middle latitudes, where temperatures are moderate and growing seasons short, than in the low latitudes where high temperatures and long growing seasons prevail. In cool climates evaporation is comparatively slow, and so a larger proportion of the moisture is available for plant growth than where temperatures are higher Twenty inches of rainfall during the growing season is more effective in Canada than in Mexico The same comparison can be made as to Sweden and Spain and for dozens of other places similarly located.

It is clear, therefore, that to express the distinction between dry and humid climates in terms of amount of annual rainfall necessarily involves an arbitrary choice of a dividing line, subject to many local exceptions Nevertheless, we must have a fairly definite idea of the amount of annual rainfall which as a rule is necessary if the climate of a given area is to be classed as humid or as dry With these limitations in mind we may consider an annual precipitation of less than 20 inches as indicative of aridity

From the standpoint of temperature, the traditional classification into torrid, temperate, and polar is too general to be useful. For that reason we prefer to recognize four broad belts which more concisely and more accurately present the actual situation; namely, the *tropical, subtropical, intermediate,* and *polar*

The *tropical climates* have no frosts, except in a few localities at relatively high altitudes; in other words, as far as temperature is concerned they have an all-year growing season. The average annual temperature is above 77°F. (25°C.) and, except

at higher altitudes, the average temperature of all months exceeds 65°F (18°C). We should not associate extremely high temperatures with this group of climates, because, with the exception of desert areas, the thermometer rarely reaches 100°F. The tropics are characterized by monotonously warm and often humid weather, with little change from day to night and from month to month. Excessive temperatures, such as those attained on the plains of the interior of the United States in the summer, are restricted to the most arid portions of the tropics.

The *subtropical climates* are those which have short, mild winters and long growing seasons. While there is a period of one to four months wherein freezing temperatures may occur, the average temperature of the coldest month is above 43°F (6°C). The summer temperatures may be fully as high as those of the tropical climates, but each year there is a short period of cooler weather wherein growth of plant life is arrested or retarded. The winters, although not severe, are sufficiently cold to break the monotony of all-year warmth and to stimulate human activity, thus making the subtropical climates desirable from the standpoint of comfort as well as of productivity. The outstanding characteristics of these climates are the long warm seasons and the short, mild, cold seasons, during which freezing temperatures may occur.

The *intermediate climates* are in fact those which prevail between the subtropical and the polar, often having both the heat of the one and the cold of the other. The term *temperate*, although long used, is so erroneous, if its real meaning is considered, that its continuance seems indefensible. The intermediate climates have cold winters and warm to hot summers. They vary from areas where the winters are short to those where they are long and severe. They all, however, have the common characteristic of a frost-free and a frost-certain season yearly, in contrast to the subtropical climates which have a frost-possible but not a frost-certain season. They are those often spoken of as the *middle latitude climates* and, in the minds of most people, are associated with the thought of great annual range in temperature, and often great diurnal range

These are the climates of rapid weather changes, caused by cyclonic storms; they are credited with being the most conducive to mental and physical activity.

The fourth great group is that of the cold or *polar climates*. They are characteristic of the high latitudes and have long, severe, cold seasons and but short summer periods of mild, rather than warm, weather. They harbor no true forests, the poleward limits of tree growth being accepted as marking the approximate limits of the intermediate climates. The milder phases of the polar climates are found in the tundra regions of northern Eurasia and North America, whereas the ice caps of Greenland and Antarctica represent the most severe phases. The polar climates are unfavorable to human life; only along their milder margins can man live, and even there the struggle is disheartening. Freezing temperatures may occur during all months, and the average temperature of the warmest month of the year is below 50°F. (10°C.)

The climates of the world may thus be classified into broad groups on the basis of rainfall and temperature. The *types* are subdivisions based on combinations of specific climatic factors; for example, the tropical climates may be further subdivided into (1) the equatorial or all-year rainy type, (2) the savanna or seasonal rainy type, (3) the tropical highland type, (4) the warm steppe, and (5) the warm desert Each has definite climatic characteristics, typical native plant and animal life, and typical economic products The same is true of the other groups, as, for example, within the group of subtropical climates we may recognize the humid subtropical or cotton belt climate of southeastern United States and the dry subtropical or mediterranean type of southern California.

The scheme of subdivision into types is shown with brief defining statements in the following outline. This outline is presented as a summary of the characteristics of the various types of climate which prevail, and it also presents a brief resume of the criteria used as the basis of classification It should be referred to frequently in connection with the more detailed discussions given in subsequent chapters.

The Major Climates of the World

I **The tropical climates.**—The all-year warm climates All months frost-free except on highlands Average temperature of coolest month is above 65°F (18°C), with a few exceptions

A *Tropical rainy type*—No prolonged and pronounced dry season Native vegetation characterized by rain forest and jungle having no seasonal leaf fall In a few cases a pronounced dry season exists, but precipitation is so high that jungle vegetation is possible—e g, along the west coast of British India Temperatures relatively monotonous, and humidity high Representative regions Guinea coast west of Dahomey, Congo Basin, Amazon Basin.

B *Tropical savanna type*—Rainfall quite plentiful most of the year, but pronounced dry season during two to four months (winter, or, rather, low-sun season) Native vegetation characterized by tall coarse grasses and scattered trees, often thorny bush Trees and shrubs suffer leaf fall during dry period Representative regions southern Sudan, much of British India, Brazilian upland, Orinoco Basin

C *Tropical highland type*—Rainfall similar to that of the tropical savanna in amount and seasonal distribution This type prevails at altitudes of about 2,500 to 6,000 feet Temperatures lower, owing to altitude Generally one to six months below 65°F (18°C) Average of coldest month above 43°F (6°C) Small seasonal range of temperature, but relatively large daily range Representative regions Rhodesian highlands, plateau of southeast Brazil

D *Tropical steppe type*—Rainfall scant Long dry season and short rainy period yearly Greater diurnal range of temperature than annual range Vegetation generally of the xerophytic bush type, acacias common, short grass in some areas Located poleward of the tropical savanna regions, the more humid aspects constituting the transition zones between savanna and true bush steppe Representative regions northern Sudan, Kalahari, and Australian steppes

E *Warm desert type*—Average annual rainfall less than 10 inches and of quite irregular occurrence High diurnal range of temperature. Vegetation very scant, in places entirely absent Representative regions Sahara, Australian Desert; Arabia, Atacama

II **The subtropical climates.**—Average temperature of coldest month is above 43°F (6°C), but below 65°F (18°C). During cool season, one to four months, temperatures may occasionally drop below freezing point, 32°F. (0°C)

F *Dry subtropical type* (*mediterranean*).—Average annual

rainfall generally below 30 inches, in some places below 20 inches. Rainfall mostly during cool season, summers nearly rainless. About six to eight months with average temperatures below 65°F. Frosts may occur during coldest period, but little interruption of growth due to low temperatures. Prevalent climatic type along west margins of continents in lower middle latitudes. Representative regions: southwestern Australia, central Chile, Mediterranean coastal lands, southern California.

G. *Humid subtropical type (sometimes referred to as the Cotton Belt climate)*.—Rainfall averages above 30 inches per year in most regions, no pronounced dry season. Generally four to six months with average temperatures below 65°F. Frost may occur during coldest period. In general, slight interruption of growth due to low temperatures. Prevalent climatic type along east margins of continents in lower middle latitudes. Representative regions: southeastern Australia, Plate River area, southeastern United States, southern China. The climate of southern China is a monsoonal variant from the true type.

III. **The intermediate climates.**—Have both frost-free and frost-certain periods each year. Hot summers and cold winters are characteristic. Continental phases with pronounced seasonal extremes occur in the interiors of North America and Eurasia, oceanic phases predominate on the west coasts of these continents. Along east coasts are ocean-modified variants from true continental conditions.

H. *Short, cold winter and long, hot summer type*.—Average temperature of coldest month below 42°F (6°C.) but not more than three months with average below freezing point (32°F.). Average annual amplitude more than 36°F. (20°C.). Average annual rainfall over 20 inches, with heaviest rainfall during the warm season. Representative regions: the corn and winter wheat belt of the United States, central Europe, northern China.

I. *Long, cold winter and short, hot summer type*.—More than three months with average temperatures below freezing point (32°F.), but also more than three months above 50°F. (10°C.). Growing season free of severe frosts three months or longer. Average annual rainfall generally above 20 inches. Heaviest rains in summer. Representative regions: Manchuria, central Russia, northern United States, southern Canada.

J. *Modified humid continental type*.—Occurs along the east coasts of North America and Asia between 35° and 50° N. latitude. Average annual temperatures not greatly different from those of the same latitudes in the continental interiors, but seasonal extremes are not so pronounced. In-

fluence of the ocean carried over the land by cyclonic storms resulting in retarded approach of seasons, in lower amplitude of seasonal temperatures, and in relatively uniform distribution of precipitation in all months of the year. Heavy winter snows in contrast with the light snowfall of continental interiors. Representative regions: New England, northern Japan.

K. *West coast marine type.*—Average annual amplitude of temperature less than 36°F. (20°C.). Rainfall quite abundant and fairly well distributed throughout the year, with tendency toward an autumn maximum. Native vegetation varies from mixed hardwoods to solid stands of conifers. Representative regions: Pacific coast of Washington and British Columbia; southern Chile; west coasts of Europe.

L. *Subpolar type.*—More than four months with average temperature below freezing point, and at most three months with average temperatures above 50°F. Rainfall lower than in other humid temperate climates, but efficient because of low rate of evaporation. Includes much of the temperate coniferous forest belt. Representative regions: Finland, northern Russia, Siberia, central Alaska, central Canada.

M. *Middle latitude steppe type.*—Low annual rainfall with summer maximum is chief characteristic. Annual rainfall 6 to 20 inches. Wide temperature variation. Low humidity in warmer areas. Natural vegetation in the cool and more humid areas varies from short grass cover to sage brush and scattered bunch grass, in warmer and less humid areas thorny bush and mesquite are dominant over the grasses. Representative regions: the Steppes of southeastern Russia, the Great Plains of North America.

N. *Middle latitude desert type.*—Similar to the steppe or semi-arid type, except that rainfall averages less than six inches per year and vegetation is scantier, varying from scattered thorny bush to complete bareness. Representative regions: Mojave desert of southern California, the Gobi desert of Mongolia.

IV. **The polar climates.**—Average temperature of warmest month is below 50°F., and freezing temperatures may occur in all months of the year. Low temperatures prevent growth of trees. Rainfall largely in form of snow, but, measured in inches of water, is not heavy.

O. *Tundra type.*—Average temperature of warmest month is above freezing but does not exceed 50°F. Some vegetation of moss and scrub bush kinds. Representative regions: northern North America and northern Siberia.

P. *Ice-cap type*—Average temperature of warmest month below 32°F No vegetation Representative regions Greenland, Antarctica.

V. **The mountain or high altitude climates.**

Q Mountain climates are characterized by such variety of differences, owing to local conditions, that definite criteria cannot be established, nor any specific general characteristics described In temperature they range from tropical to polar, and in vegetation from rain forest to desert

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CHAPTER XVI

The Regions of Tropical Humid Climates

THE warm climates are of special interest because they are so different from those with which most of us are familiar We are accustomed to marked temperature changes from summer to winter; the tropical climates have no such seasonal extremes. We are accustomed to sudden changes from cold to warm or vice versa; such changes are unknown in the tropical lands. When the bitter cold of winter comes to the middle latitudes the thought of a climate that is always warm is an alluring one. Nevertheless, the monotony of conditions in the tropics—and more particularly the continual warmth and dampness of the tropical rainy regions—is anything but beneficial to man, whether he be white, brown, or black.

That man is greatly affected physically by his climatic environment is beyond question. The energy turnover in his body is closely related to temperature and humidity. The air man exhales is of body temperature (98°F.) and contains much water vapor. In cold and dry climates he must supply energy not only to heat this air but also to evaporate the necessary amount of water from his body. Besides, he needs to generate considerable heat to protect his body from too much cooling. In warm, moist climates, on the other hand, but little energy is needed to bring the air in the lungs to body temperature and saturate it with moisture, and there is no danger of too much cooling of the body. Man in the colder climates needs to eat more substantial foods, and the climatic environment makes possible greater physical and, perhaps, mental activity. Since it can be counter-balanced only by more copious perspiration, extra bodily heat developed by muscular activity becomes dangerous much sooner in warm climates than in cool. Thus, it does not seem strange that man in the middle latitudes

is generally more energetic and displays more initiative than does his brother in the warm and humid tropics

Since people in the tropics must live quite differently than those of us who are inhabitants of the cooler latitudes, and since plant and animal life are also quite dissimilar, popular interest in those regions has always been great The Indians of the Amazon forest, the natives of Borneo, the pygmies and the negroes of the Congo all appeal to our curiosity because they typify lands and conditions so radically different from our own. The lure of the tropics is real, not only to seasoned travelers, but to the stay-at-homes as well

The tropical rainy climates form a broad equatorial band around the earth, extending beyond the Tropics of Cancer and Capricorn in some areas, although not quite reaching them in others As to their general characteristics, let us at the outset dispel two commonly held notions—namely, (1) that they are always rainy and, (2) that they are excessively hot.

On the whole, the greatest amount of annual rainfall occurs in the equatorial belt, decreasing both northward and southward; but even where it is high, 100 inches or more, most of it comes as heavy showers, often in late afternoon or at night, and brilliant sunshine prevails during most of the days This is an important factor in accounting for the rapid growth of vegetation in such areas. Contrary to popular belief, temperatures are not often excessively high. During the month of July higher temperatures usually occur in the interior of United States than are ever encountered in most places near the equator. On the other hand, there is no cold period, and the humidity is relatively high. These factors give rise to a monotonous climate, warm and humid month after month, which proves quite enervating, particularly to those who are accustomed to the invigorating influences induced by quick changes from warm to cold.

Within the belt of warm humid climates three major climatic types may be recognized, each extending over large areas These are: (1) the tropical rainy type, where all the months are warm and rainy without any pronounced dry season, and where

the daily and annual ranges of temperature are slight; (2) the tropical savanna type, with pronounced wet and dry seasons, and low range of temperature, (3) the tropical highland type, having all-year warmth, but with distinctly seasonal rainfall and marked diurnal range of temperature Each of these types is of such importance that it warrants rather full study of its climatic characteristics, its regional distribution, and the geographic relationships which it entails

THE TROPICAL RAINY TYPE OF CLIMATE

The principal characteristic which distinguishes the tropical rainy from other types of warm, humid climates is the absence of a pronounced dry season. In general, regions having this type of climate are located in the equatorial belt, ranging only a few degrees north and south of the equator except for some narrow coastal strips which extend nearly to the Tropics of Cancer and Capricorn. The three major regions which come under this classification are (1) the East Indies and the adjacent portions of Asia; (2) the Congo Basin and Guinea coast of Africa; and (3) the Amazon lowland of South America All owe their climatic characteristics chiefly to their location near the equator. There annual insolation is highest and the heating of the air causes expansion and ascending currents, thus forcing moisture-laden air upward to where adiabatic cooling produces heavy precipitation.

Smaller areas with essentially the same type of climate occur along eastern coasts where the trade winds, blowing onshore from warm oceans, are forced to ascend mountains or plateaus, as in Brazil, the West Indies, or Central America There are numerous instances where the lowlands up to 1,000 feet are desert-like, while the higher slopes are rain drenched. This is notably true along the north coast of Venezuela and part of the east coast of Brazil.

Temperature characteristics.—The temperatures are not exceptionally high, averaging generally about 75°-85°F. Monotony is the dominant feature The difference between the average temperature of the warmest and of the coolest month

rarely exceeds five degrees, and in some cases it is only about two degrees Fahrenheit. The diurnal range is ordinarily much greater than the annual range, but in some districts nights are less than 10 degrees cooler than the midday periods Temperatures above 90°F. are not common, but on the other hand even

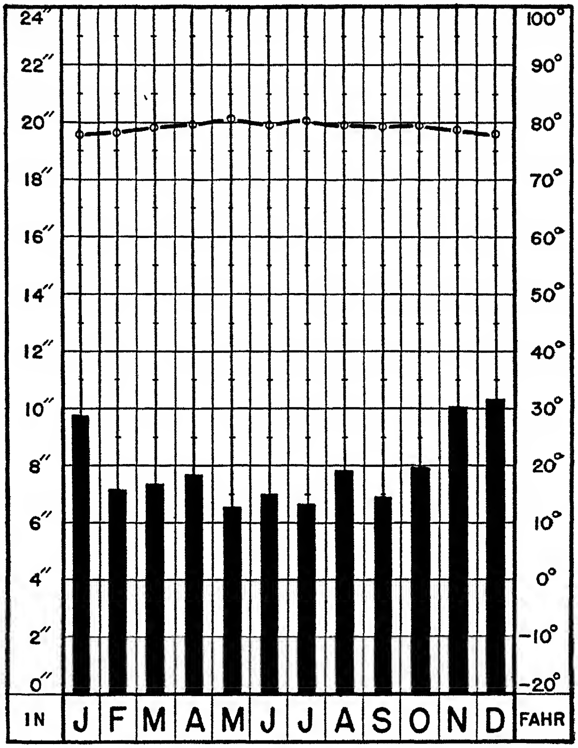


Fig. 169.—Tropical rainy climate. Average temperature and precipitation, Singapore. Altitude 15 feet, total precipitation 95 inches.

the coolest nights seldom drop to 60°, and for long periods night time temperatures of 75° or more may prevail.

Winds.—The tropical rainy type of climate is characterized by light winds and calms. The middle portion of this belt is the area of equatorial calms, where the general air movement is one of slow ascent, and surface winds therefore are light and variable Squalls and thunderstorms of short duration occur frequently. The destructive storms often associated with trop-

ical climates are not characteristic of the all-year rainy areas; this is a factor of great economic significance for tropical commercial agriculture.

Rainfall and humidity.—Humidity is generally high. In many areas it averages 80 per cent or more, and periods of 90

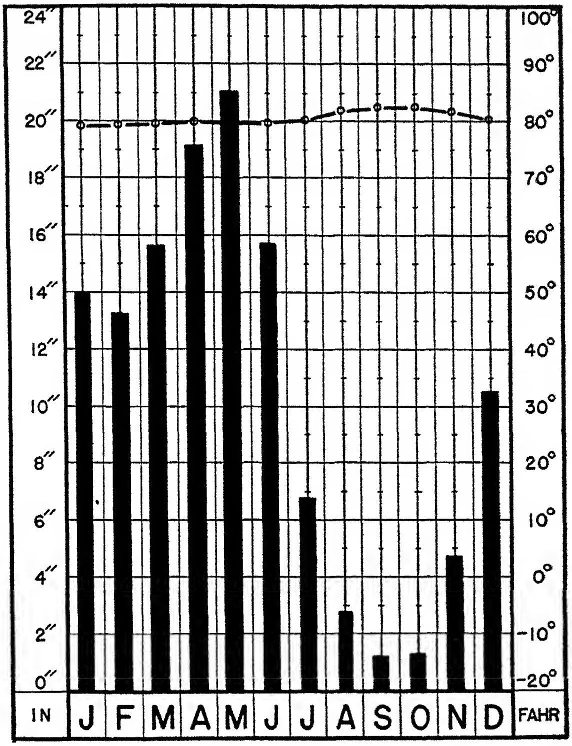


Fig. 170.—Tropical rainy climate Average temperature and precipitation, Cayenne, French Guiana. Altitude 18 feet, total precipitation 126 inches.

per cent are not uncommon. The total annual rainfall is ordinarily in excess of 60 inches, and some places have from 150 to 200 inches a year The rain comes at quite regular hours during the day, mostly as heavy showers which last but a short time and are succeeded by brilliant, almost dazzling, sunshine. The more prolonged rains occur at night, but the latter part of the night time is not rainy, and the morning hours are usually clear Even where the rainfall is heavy the percentage of

sunshine is high; it is this combination of abundance of rain with much sunshine and persistent warmth which promotes the dense growth of vegetation so characteristic of areas having this type of climate.

The outstanding features of the tropical rainy climate may be summarized, therefore, by stating that for the most part winds are gentle, temperatures warm and monotonous but not hot, and rainfall abundant, varying seasonally and from year to year but with most months quite rainy Where so-called dry seasons occur, they are neither prolonged nor severe and some rain usually falls even in the driest month. The monotony of temperature and the lack of sharp changes is tiresome and tends to reduce the desire of people to work zealously and at high speed "Eternal summer" is a catchy expression, but in the long run the even temperatures of the tropics are not so pleasant as are the ever changing temperatures of the middle latitudes The variable weather of the middle latitudes is invigorating, the eternal summer of the Tropics is enervating

Native flora and fauna.—The climatic conditions just described quite naturally result in a luxuriant growth of vegetation, varying from rain-forests, where the tree growth is so dense as to leave but little opportunity for underbrush, to the tropical jungle, with its maze of trees, shrubs, and vines In the tropical rainy regions there are no common periods of flowering and fruitage for all the vegetation, and there is no distinct seasonal leaf fall Broad-leaved evergreens characterize the landscape The forest consists of an intimate mixture of a great variety of trees quite in contrast to the solid stands which are typical for the forests of higher latitudes

Since dense vegetation dominates the land, the animal life has adapted itself to living in the trees rather than to burrowing into the ground The fauna is made up largely of the flying or climbing types—such as monkeys, snakes, birds and insects—and there are but few strictly ground-dwelling species, and almost none of the burrowing type. Monkeys, constrictors, and green parrots are ubiquitous. The birds and insects are characterized by brilliant, even gaudy colors, among which reds,

blues, and greens are the most common The streams harbor reptiles and mammals as well as many species of fish There is the home of the alligator, crocodile, and hippopotamus Abundance of vegetation ordinarily fosters abundant and varied animal life, but the dense jungle furnishes such admirable hiding places that an uninitiated traveler is likely to see little evi-

Courtesy, Ministère des Colonies de Belgique

Fig. 171.—Equatorial forest vegetation in the Belgian Congo. Note dense undergrowth and the vine-like lianas suspended from the branches of the trees.

dence of the numerous animals which watch him from their sheltered retreats. Thus the stranger in the jungle is led to believe that the uncanny silence in which he finds himself is indicative of scarceness of animal life, when as a matter of fact his every movement is being watched by many eyes

Soils (introductory statements concerning soils in general).—The soil is the upper part of the mantle rock, which, as a result of physical and chemical changes—owing to weathering in general and the activity of water in particular, to the presence of vegetation, and to other factors—has developed certain characteristics of its own. This development often makes the soil into something radically different, both physically and chemically, from the underlying material from which it was derived. It has been generally recognized that soils pass through cycles of development, and on the basis of this observation they can be referred to as young, mature, or old, according the stage of development they may have reached.

Young soils are incompletely developed and often occupy slopes, where erosion prevents further development, or they occupy flood plain areas where the cycle of evolution is frequently interrupted by deposition of new sediments.

Mature soils are those which, undisturbed by erosion or deposition, have acquired characteristics distinctly different from those of the underlying material. Such soils occur mostly on well drained, rather level surfaces, on terraces, and on smooth to gently rolling upland areas.

Old soils have reached a stage in their development in which their characteristic features are well expressed and exist where they have remained undisturbed for long periods of time. Young, mature and old soils may exist in the same region, side by side, and represent only different stages in the same evolutionary process.

The evolutionary processes are not the same in all parts of the world. Various schemes of classification have been suggested by different writers, most of them being rather complicated in order to accommodate the many classes of soils which are known to exist. The simplest scheme, proposed by Marbut,[1] is used widely by American writers and has received considerable recognition abroad. In this scheme all soils may be included in two great groups—namely, the *pedocals* and the *pedalfers*. As

[1] Marbut, Curtis F. "A Scheme for Soil Classification," *Proceedings and Papers of the National Soils Congress,* Vol IX (Commission V), 1928.

the names imply, the former are rich in lime—that is, they are lime-accumulating in the upper horizon—while the latter are characterized by a relatively high iron and alumina content and, as a result of leaching by soil water, are not lime-accumulating. In fact, pedalfers are often deficient in lime and usually tend toward acidity, whereas pedocals give alkaline reactions. In any mature soil the amount of lime is directly related to the moisture conditions under which the soil has been developed. The mature soils in arid and semi-arid areas are generally rich in lime, whereas in areas of abundant rainfall they are deficient. Since rainy lands usually are forest covered, whereas sub-humid lands are prairies and steppes, the pedalfers are known also as forest soils and the pedocals as grassland soils. But in such a generalization we must recognize the exception of the prairies of the United States as well as the wet savanna lands found in many parts of the world, all of which are grassland soils but are not lime-accumulating

Since lime is needed by most agricultural crops, its presence in the soil is a mark of fertility Besides, if lime is present in plentiful quantities, other soluble minerals essential for plant growth—such as phosphates, nitrates, and potash—are usually also available more or less abundantly. Such soils rank high in fertility for two reasons, namely, (1) the essential mineral constituents are present in such form and in such quantities that they can serve as plant foods, and (2) the presence of such minerals is conducive to a stable soil structure, favorable for both tillage and plant growth. Acid soils, on the other hand, are weak in the essential plant foods named above, and usually their physical structure is less favorable for tillage and for the production of grain crops and legumes than that of the soils which are rich in lime.

The soils of the rainy tropics.—Owing to heavy precipitation and relatively high temperatures throughout the year, the soils of the tropical rainy regions are subject to continual and vigorous leaching, and hence they must be classed as pedalfers. Leaching may go so far that even the silica of the silicate minerals disappears, and that eventually little may be left but an

infertile mixture of aluminum and iron hydroxides, with a slight admixture of humus These processes of intense leaching are characteristic of all regions of humid tropical climates, and they lead to the formation of various types of so called *lateritic* soils, even of pure *laterite,* the infertile mixture referred to above While the latter probably ranks as the poorest soil in the world, the lateritic soils, in which the processes of leaching have not yet reached the final phase, also are usually deficient in most or all of the essential plant foods and often have a very poor physical structure.

Thus it is evident that, in general, tropical soils are not so fertile as they have been described by some writers whose observations were limited to the young alluvial lands bordering the streams. For successful agriculture, liberal applications of fertilizer are desirable and often necessary, and careful methods of tillage must be employed if productivity is to be maintained for more than three or four years after the clearing of the virgin forest.

Some laterites, and many approximations to them, are found in the rainy tropics where leaching takes place throughout the year, as in parts of Borneo, Celebes, and Sumatra, in the interior of the Congo basin, along the Guinea coast, in parts of the Amazon basin, and in the Guianas The color of these soils is generally a yellowish to reddish brown in their upper horizon, except for a thin layer colored dark by humus at the top Below this follows at varying depths a dark ochre-yellow or mottled yellow and red horizon, which is rich in iron and quite compact. Farther down follows a still harder horizon where the material has been cemented by silicates washed in from above. Usually these soils are heavy, and they become hard and compact upon drying In some cases it is necessary to use dynamite in order to break them up for proper aeration Great care must be taken not to plow or otherwise stir them when they are too wet.

Where the lateritic soils periodically dry out—that is, where a pronounced dry season occurs—the brownish-yellowish color of the upper horizon turns into a bright red Until recently this

bright red color was considered indicative of pure laterite (LATIN, *later*=brick), but at present many of these soils are classified as *tropical or lateritic rederths* Their principal area of distribution lies within the regions of tropical savanna climate.

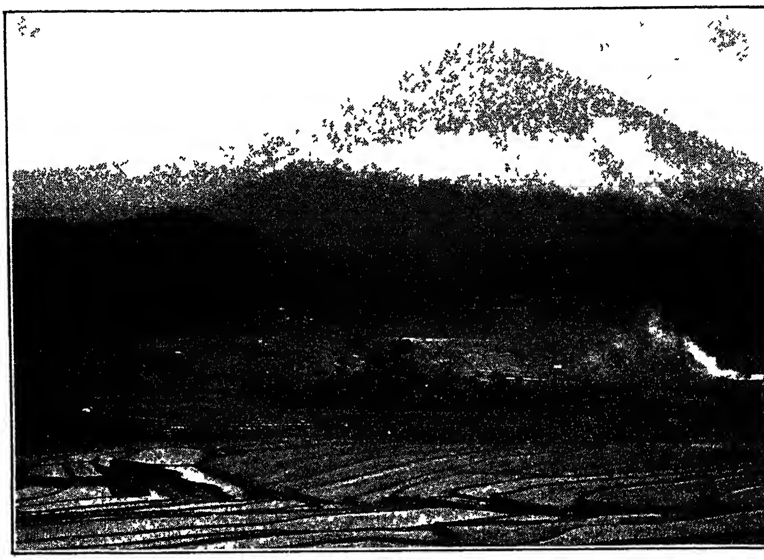
In the tropical rainy regions, there are, however, two general groups of soils that are highly productive; namely, (1) the young upland soils which result from the rapid weathering of recent lavas, and (2) the alluvial soils which have recently been built up along many of the stream courses, or which have been washed down from the mountains and deposited as alluvial fans, in some cases merging into piedmont plains. Java and the rainy slopes of the Hawaiian islands are well known examples of the former; and the eastern coast of Central America, the famous banana land, is an illustration of the latter. In both Java and Hawaii recent volcanics with varied mineral content weather so rapidly that modern agriculture is favored by unceasing liberation of soluble salts, and such lands produce abundantly whereas older soils similarly tilled give but slight returns.

Agriculture.—The climate, the dense forest, and the generally poor soils are the most important environmental factors in retarding agricultural development in the tropical rainy regions of the world Tropical forest areas are difficult to clear; trees are large and much underbrush must be chopped out, and unless constant vigilance is practiced, the latter soon reclaims the land because of its vigorous, incessant growth.

Although the virgin soil may be productive, on slope lands the fertility is not such as to give large yields for an extended period of years. Cleared uplands usually yield fairly well for a few years and then decline. The lessened productivity is due not only to the leaching of soluble salts from the soil, but also to the loss of the soil itself through erosion. In native agriculture the decline is so rapid and severe that in most places lands are abandoned after three to seven years of farming New lands are then cleared and the old ones permitted to revert to brush and jungle. In the tropical rainy regions the greatest densities of rural population seem to coincide with regions of recent

volcanic activity, where decomposition of basic ash and lavas occurs rapidly and where these volcanic materials are so young that leaching has not yet succeeded in impoverishing the soils. This is well illustrated in Java, Costa Rica, and Salvador.

Among other handicaps facing tropical agriculture is the prevalence of plant and animal pests and diseases. Warm, humid climates with a total absence of frost are conducive not only to an abundance of insect life, but also to the development of fungi and all sorts of micro-organisms. Commercial planta-



Courtesy, Department van Landbouw, Netherland India

Fig. 172.—Highly developed agriculture in the tropics Terraced rice fields in western Java. Note volcanic cone in the background.

tions of various kinds have been ruined because of the attack of some disease against which the scientist has proved powerless, as, for example, the coffee plantations in parts of the Far East which were destroyed by a fungus attacking the leaves, and the cacao plantations of Ecuador which are threatened with destruction by the dreaded witch broom disease. Entire districts in parts of Central America have had to abandon banana production because of the ravages of blight. Furthermore, fungi and insects quickly attack stored products unless

precautionary measures, nearly always expensive, are rigorously carried out Many tropical products are highly perishable and must be marketed promptly to avoid deterioration, and hence long time storage and orderly sale in response to market demands, such as characterizes the marketing of grain crops in the middle latitudes, is impossible

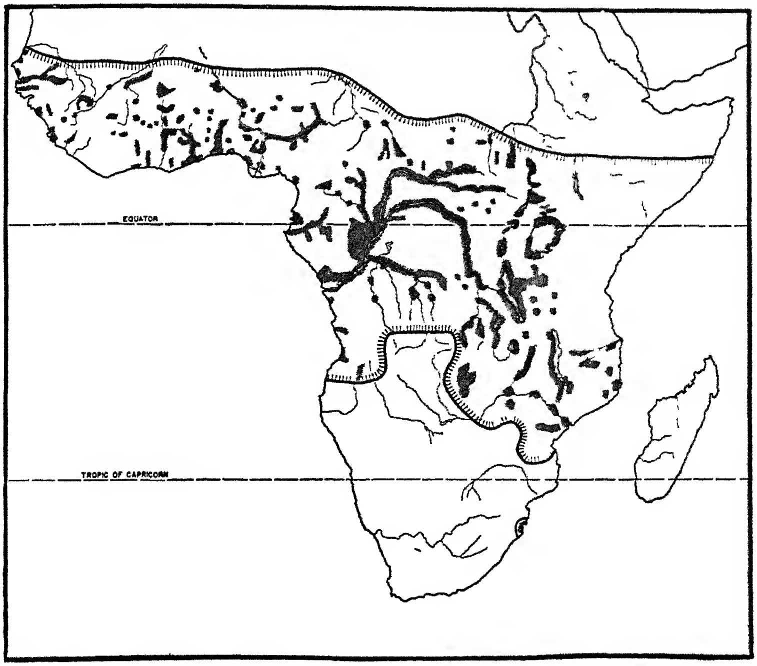


Fig. 173.—Distribution of *Glossina palpalis* and *Glossina morsitans* (tse-tse flies), carriers of the germs which cause sleeping sickness. In areas infested by tse-tse flies it is impossible to have any domestic animals on account of the ravages of the disease. (After W. Frantzen *Matériaux pour l'étude des calamités*, No 16, Geneva, 1928)

Sustenance agriculture as carried on by the native peoples is primitive and mostly of the patch farming type The general practice is to make a small clearing and farm it for a few years, until the productivity falls so low that it must be abandoned, and then proceed to make a new clearing Fortunately, under the stable climatic conditions crop failures rarely occur. Uncultivated edible products are available, the

population over most of the areas is relatively sparse, and the standards of living are low Rice, roots, fruits, nuts, and game are the chief features of the diet Fish are generally plentiful and but little other meat is needed.

Where the native population is dense, as in parts of southeastern Asia and in the East Indies, sustenance agriculture is of a much more advanced type; agricultural processes are more efficiently organized and productivity is maintained by the same methods of tillage, crop rotation, and use of fertilizers which prevail in the so-called modern countries

Photo by N A B

Fig. 174.—Patch farming in the tropics Corn raised for human consumption, Honduras, Central America.

Commercial agriculture is, however, mostly of the highly organized estate or plantation type and specializes in products for the world market, as, for example, sugar, bananas, coconuts, cacao, and rubber Under the estate system the establishment and management of the plantations are under the control of people and capital from the northern climates. In a large measure the estates embody the latest advances of scientific knowledge, engineering skill, and economic practice

Establishing the plantation.—While practices differ with crops and districts, the procedures followed in establishing agricultural plantations in tropical lands show much similarity

The steps taken are usually of about this order. (1) the land is investigated carefully as to soils, slopes, drainage, forest cover, and local climatic conditions, (2) the land selected is then surveyed, and the location, size, and form of the field units are determined, (3) farm headquarters are established and the necessary construction program is inaugurated to provide water supplies, living accommodations for the white employees and native laborers, pastures for draft animals, and warehouses for materials and supplies; (4) the underbrush is cleared with machetes and small axes, and the slash is burned; (5) the large

Photo by N A B

FIG. 175.—Plantation agriculture in the tropics. Banana farm in the Motagua valley, Guatemala.

trees are felled, and some of the logs are used for timber while others are left where they fall; (6) roadways are built to serve the individual farm units, and often tramways are extended into the fields to be used in hauling out the harvested products; (7) in some cases drainage ditches must be constructed, in others ditches for irrigation, and in still other instances both drainage and irrigation must be provided to take care of heavy floods during wet seasons and of droughts during the dry seasons, either of which may prove disastrous to the growing crops.

The most efficient use of the lands of the humid tropics in-

volves scientific practices of a high order if economic success is to be attained In addition to the steps outlined above, it usually is necessary for the plantation owners to provide medical and hospital services, school facilities, and recreation centers Economic welfare is dependent upon the maintenance of a community wherein the white officials and the native labor are healthy, energetic, and cheerful. Facilities to promote such results involve expense, but general experience indicates that the outlays are economically as well as humanely sound.

THE TROPICAL SAVANNA TYPE OF CLIMATE

The tropical savanna type of climate has a long rainy season and a short but pronounced dry season. The distinctly seasonal distribution of rainfall is the chief difference between this and the tropical rainy type, although in general the total amount of precipitation in this case is less also. Another difference, of lesser consequence, however, is that the seasonal temperature range is somewhat greater, owing mostly to the higher latitudes in which this climatic type occurs.

A glance at the map will show that the tropical savanna climate is probably more extensive than any other. On the whole it occurs north and south of the tropical rainy areas, extending ten or more degrees of latitude beyond them on either side, thus marking the first stage in the gradual transition from rainy to dry The principal areas where it is well developed are the southern Sudan of Africa, parts of British India and Siam, northern Australia, the Brazilian campos, the Orinoco Basin, the west coast of Central America, and southern Mexico including much of Yucatan It will be noted that in the western hemisphere the areas of seasonal rainy climates occur mostly along the west coast and in the interior, and that much of the east coast has the all-year rainy type.

Winds.—The tropical savanna type of climate extends far enough north and south of the equatorial zone to include large portions of the trade wind belts As already mentioned (page 43), the sun's rays strike the earth at constantly changing

angles. The noonday sun is vertical at the Tropic of Capricorn on December 22, at the Equator on March 21, at the Tropic of Cancer on June 21, and again at the Equator about September 22 Thus, in the course of a year, all places on the globe have a high-sun period and a low-sun period, in fact near the Equator there are two of each, although the difference between the high and low-sun positions is not great. At distances of 10 degrees or more from the Equator, however, these periods are well marked, and of course insolation is relatively great during the high-sun period and appreciably less during the low-sun period As the sun's position moves northward and southward, pressure and wind belts follow suit. Although this shift is not great in the tropical savanna regions, which are located relatively close to the Equator, it is sufficient to bring about a slight seasonal rhythm in temperature and a much more pronounced rhythm in rainfall. During the high-sun period, when the noonday sun stands practically overhead, insolation is at its maximum. The heated air expands and rises, and surface winds are weak and irregular as the trade winds recede poleward. This is the rainy season. During the low-sun period the trade winds reassert themselves Since they blow toward warmer regions, they give little or no rain except where intercepted by mountains. The low-sun period is therefore the season of drought.

Temperature.—Temperatures are similar to those prevalent in the tropical rainy regions, the chief difference being a somewhat greater seasonal range In general no month averages below 65°F. As a rule the highest temperatures immediately precede the period of maximum rainfall In the Sudan the hottest months are April and May. In June, when the rains are quite copious, temperatures drop. In Bengal rains are welcomed because they are accompanied by lower temperatures and thus bring relief from the excessive heat of the preceding weeks

On the whole, because of the range of temperature and humidity, the regions of the tropical savannas escape the extreme monotony so characteristic of the tropical rainy belt, and the

climate is therefore much more conducive to physical and mental activity.

Rainfall.—The rainfall, although abundant, is not excessive. The annual precipitation in different regions varies from 30 to 60 inches, the former being so low that, because of the all-year warmth, it results in a condition bordering on semi-arid. The

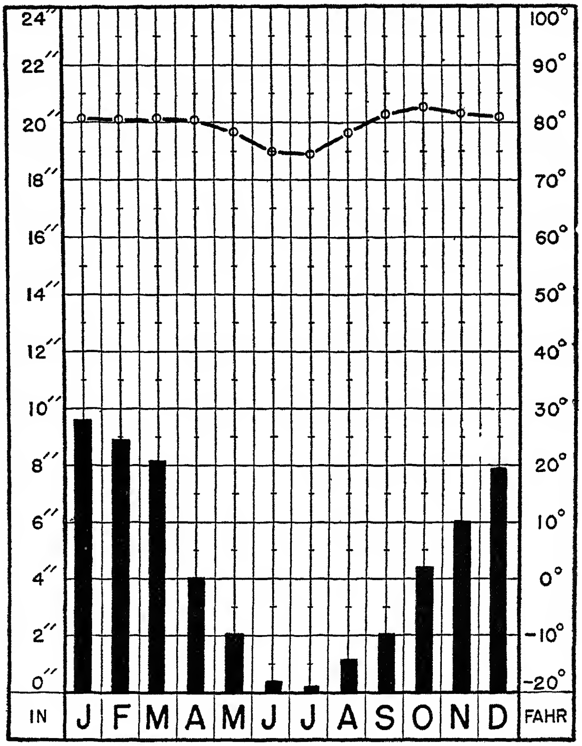


Fig. 176.—Savanna climate Average temperature and precipitation, Cuyaba, south-central Brazil. Altitude 495 feet, total precipitation 55 inches.

higher figure represents not the maximum but the average maximum, which only few and restricted areas exceed.

Marked seasonal distribution is the most prominent characteristic of the rainfall The length of the rainy season varies in different sections of the tropical savannas from eight to less than five months Toward the Equator the dry season is comparatively brief, increasing in duration with distance from it

The height of the rainy season is a period of heavy precipitation, while that of the dry season is rainless During the rainy season roads and trails are muddy, in places almost impassable, while during the latter part of the dry season they are thickly laden with dust These pronounced seasonal changes involve greater efforts at adjustment on the part of man than are necessary under a more monotonous regime of rainfall. Storage of food for people and feed for animals is necessary because the dry season is one of low productivity and resulting scarcity The population cannot lead the hand-to-mouth existence which is so often typical of the inhabitants of the rainy tropics.

Tropical cyclones—storms to be feared.—Another of the marked characteristics of this type of climate are the tropical cyclones which originate over the seas but which sometimes cause great havoc on islands, or along the coasts of continents These storms develop over the oceans in latitudes 10 to 20 degrees north and south of the equator and thence follow roughly semi-elliptical paths, first westward then eastward, toward higher latitudes They are known in different sections by the terms *hurricane, typhoon,* and *tropical cyclone*. The term *hurricane* is restricted to the West Indies and neighboring waters of the North Atlantic and to the western South Pacific and Australia In the northwestern Pacific Ocean and the China Sea, tropical storms of this type are called *typhoons*. In the Indian Ocean they retain the name *cyclone,* originally given them by the early English mariners

While many of the tropical cyclones do not develop destructive violence, some reach intensities which rank them among the most severe storms known In such cases there is a moderate decrease in atmospheric pressure to within 30 to 50 miles of the center, after which a pronounced and rapid fall occurs This steep pressure-gradient marks the area within which violent winds and excessive rainfall often cause disastrous losses. While the atmospheric disturbance created by the tropical cyclones may extend over very large areas, the really dangerous and destructive center generally has a diameter of less than 200 miles. Tropical cyclones usually lose their violent energy soon

after striking continental land masses, and therefore they generally affect interior points through heavy downpours rather than by high winds. On the islands and along the coasts the destructive effects upon crops and buildings are often appalling. Wind velocities exceeding 100 miles an hour are frequently experienced; in such cases crops are ruined, trees are uprooted, and buildings are blown down This hazard is one of the most serious handicaps to agriculture within the areas subject to these tropical storms.

Photo by H L Shantz

Fig. 177.—Tall-grass savanna in the Anglo-Egyptian Sudan. Note tall grass interspersed with trees, mostly acacias.

Native vegetation.—The native flora in regions of the tropical savanna type of climate varies from deciduous forest to grass. The most widespread type is the savanna, that is, a grassland mantled with tall, coarse grasses, and dotted with clumps of deciduous trees. In some areas the trees occupy such a large percentage of the uplands that grass is not abundant; elsewhere only scattered trees or clumps of trees break the monotony of the grassy plain, while along the courses of major streams, es-

climate harbors the elephant, hippopotamus, rhinoceros, and zebra, while the giraffe, warthog, and other animals which are fleet of foot inhabit the drier sections. In the jungle areas within the savannas are found the tiger and cougar, while in the tall-grass savanna the lion is the king of beasts. In general, the animals which characterize the well-wooded and tall grass savannas are large and well fed. The numerous varieties include arboreal, aquatic, and ground types, not any one of them strongly predominant. On the whole they are less arboreal than those of the jungle and rain-forest, and less fleet footed than those of the dry savannas. They include species larger and stronger than their neighbors of either the humid or of the semi-arid bordering regions.

Soils.—The tropical savanna soils are yellow or reddish, usually more deeply colored than are those of the tropical forest lands. These soils occur in areas where the rainfall is not so heavy and the temperatures during part of the year are lower than they are in the equatorial belt. The tropical rederths and yellowerths belong to the group of lateritic soils, and as such they are weak in humus and soluble mineral plant foods. Since they have developed in regions where rainfall is not so heavy, the savanna soils are not so thoroughly leached as are the soils of the rainy tropics and have a somewhat better physical structure and a subsoil which is less compact After the land is cleared the soils are ordinarily quite productive for a few years, but they quickly deteriorate unless mineral fertilizers are applied In native agriculture, which is mostly of the "patch" type, the common practice is to clear new land every three or four years and let the old field revert to brush In some parts of the West Indies and Central America this process has been followed even in native sugar cane production on a fairly large scale It is a practice that can, of course, only prevail where the population is sparse and land plentiful; where the population is dense or where plantation agriculture is highly developed, the productivity of the land must be maintained by means of application of fertilizers.

Since the tropical savannas constitute a transition zone from

humid to semi-arid lands, there is, of course, a similar transition in soil characteristics The soils of the rainy, equatorward areas are lateritic; they are more thoroughly leached than are the soils of the drier and somewhat cooler areas which lie farther from the rainy belt. Since the latter are subject to less leaching, the content of soluble salts is higher, the color tends more toward gray than red, and the sub-soil is more friable. In general, the soils of the drier parts of the savanna rank higher in fertility than do those of the rainier areas, and they are more easily tilled. In these lands, as elsewhere, the alluvial lands along streams or along mountain fronts are generally fertile and highly productive because their soils are the result of deposition of the richest detritus washed down from higher, weathered slopes

Agriculture.—The savanna climate is probably the most favorable type for agriculture to be found in the tropics. Its capacity to sustain population is well shown in British India, Indo-China, and parts of the Sudan. Population maps reveal extensive areas of moderate to dense population where this climate prevails, quite in contrast to the few areas of density found in the rainy equatorial belt The dense populations supported in the seasonal-rainy areas in southern Asia indicate interesting potentialities for the vast, sparsely peopled areas of Africa and South America when the pressure of increasing world population may make it necessary to turn these lands into active productivity

Areas of this type of climate have a number of distinct advantages The dry season gives man more energy than is the case where all months are warm and rainy Clearing the land is easier, since the forest stand if any, is less dense The young trees, the dead grass, and the slash from clearing bush and trees can easily be burned during the dry season. The ground can be plowed and planted at the beginning of the wet season. Grasses do well, and grains can be produced advantageously. The rainy season is the growing season; the dry season is harvest time, and the dry air which marks it favors complete ripening and hardening of the grain, thus rendering the stored products

less subject to attack by fungi or insects. The grains typical of these regions are many kinds of sorghum and millet besides corn and, where irrigation is possible, rice Sugar cane is a staple crop for local consumption, and in some places cane sugar takes high rank as an export commodity as well. Cotton is grown for local clothing material, and its cultivation has also important commercial possibilities. On the whole, the savanna lands are the centers of the most extensive agriculture in the tropics, particularly the agriculture of the farmer type in contrast to the plantation system so dominant in the all-year wet and warm regions.

THE TROPICAL HIGHLAND TYPE OF CLIMATE

The tropical highlands differ from the lowlands in having somewhat lower average annual temperatures and greater daily rhythm of temperature. Because of the small number of stations with long weather records located within the tropical highlands, the regions as shown on the map (Fig. 300) have been delineated on the two-fold bases of available climatological data and elevation above sea level. Most of the areas included in the tropical highland type of climate lie at altitudes between 2,000 and 6,000 feet above sea level, but there are some notable exceptions where greater heights are reached, as in Ethiopia and southern Mexico

The largest area is in Africa, extending from Lake Victoria southward and westward across the headwater districts of the Congo and Zambesi rivers; smaller ones include Ethiopia, and the highlands of south Africa and of Madagascar Important areas outside of Africa occur in southern Arabia, southern Brazil, and southern Mexico

Essential characteristics.—Cooler temperature in comparison with the adjacent lowlands is the outstanding feature of the tropical highland type of climate The average annual temperatures vary from about 65° to 72°F., and the difference between the mean temperatures of the warmest and coldest months of the year is often less than 10 degrees The warmest months are of course associated with the high-sun seasons, the

temperatures then averaging from 68° to 78°F. The coldest months occur during the low-sun periods, with averages from 45° to 65°F. The difference between daytime and night temperatures is fairly pronounced. Warm to hot days and clear, cool nights are typical; frosts are rare but may occur at the highest altitudes

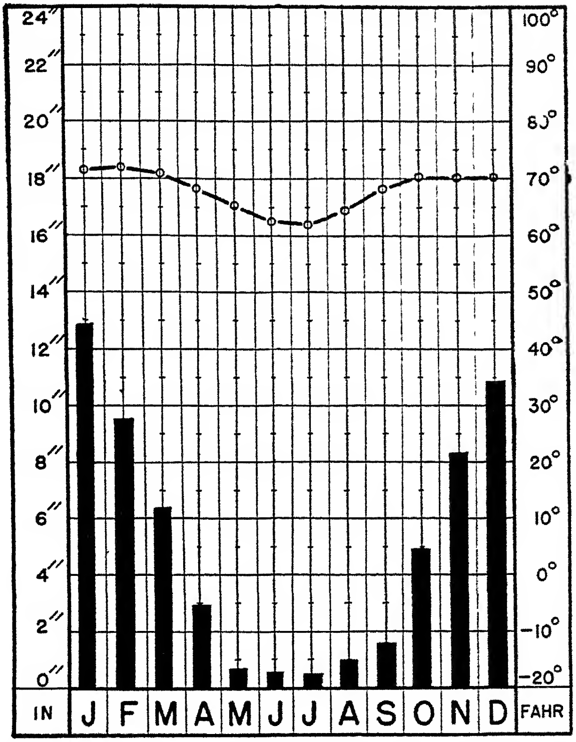


Fig 179.—Tropical highland climate. Average temperature and precipitation, Bello Horizonte, north of Rio Janeiro, Brazil. Altitude 2,571 feet, total precipitation 59 inches.

Rainfall is usually ample, but varies greatly in different regions, some having only about 30 inches per year whereas certain others receive up to 80 inches and more; 40 to 60 inches can be considered a fair average. Periodicity of rainfall is pronounced everywhere. The rainy season occurs during the high-sun period of the year, while the culmination of the dry season and the low-sun period are practically simultaneous. For areas

south of the equator July is usually the driest month, while the rainy season lasts from October to April, the rainiest month occurring within that period but varying locally. North of the equator opposite conditions prevail.

The trades are the dominant winds, and they serve the doubly useful purpose of bringing in moisture and of rendering living conditions more pleasant through their steady breezes On the whole, climatic conditions are quite favorable for human activities, a fact attested by such progressive people as inhabit the highlands of eastern Brazil and southern Mexico.

STATIONS IN THE HIGH TROPICAL CLIMATES

	Altitude in feet	Temperature (Fahrenheit)					Rainfall (inches)		
		Ave Annual	Warmest Month	Coldest Month	Known Warm	Extreme Cold	Ave Annual	Wettest Month	Driest Month
Africa									
Katanga	4,034	68°	73° Nov	58° June	97°	36°	48	10 6 Jan	0 July
Mamba	5,084	64°	68° Feb	58° July			60	10 2 April 7 1 Nov	2 7 Sept
Tabora	3,970	72°	78°	68°	97°	50°	33 4	6 5 March	0 July
South America									
Uberaba	2,493	71°	74°	65°	91°	34°	68	12 2 Jan	4 July
Sao Paulo	2,493	65°	69°	58°	91°	36°	51	8 3 Jan	8 July

Native flora.—The native vegetation varies from forest to short grass and scrubby bush. The rainfall, although fairly heavy, is not sufficiently well distributed to support dense forest except in some favored localities In general, scattered tree growth, low, often thorny scrub, and grass prevail, as for example in Africa east and south of Lake Victoria. In some of the highlands of Africa, as in Angola and northern Rhodesia, are open forests with trees 30 feet or more high, yet not dense enough to suppress a grass cover. Some kinds of trees form nearly pure stands, but usually the stems are crooked and

twisted. In other regions there are areas where tree growth is so sparse that the problem of obtaining wood for cooking purposes is a handicap to settlement The higher slopes are usually forested, and the higher parts of the plateaus are favored with a grass cover wherever the tree stand is fairly open. This is especially true of the Abyssinian Plateau and of the mountain slopelands above the Valley of Mexico.

Photo by H L Shantz

Fig. 180.—Open deciduous forest of northern Rhodesia, Africa. Seasonal leaf-fall due to seasonal drought

The growth of grass, trees, and shrubs bespeaks the prevalent fertility of the soil of these areas. This is due in no small measure to the moderate amount of rainfall and to its seasonal distribution, both factors tending to conserve the soil and its soluble elements formed as a result of rock weathering in place

Soils.—The upland soils of the tropical highlands are partly red-and-yellowerths similar to those of the rainier sections of the savanna lands; others have some characteristics similar to

those of the extra-tropical blackerths, especially where rainfall is low and a grass vegetation prevails. This latter type of soil is usually very fertile.

Since the altitudes are greater, valleys have been eroded rather deeply in most areas, and the topography is much more rugged than that of lower lands. As a result of the more active erosion, the soils are younger and are more directly related to the bedrock from which they were derived. Fully developed, mature soils are not common in rugged uplands, and thus the lateritic characteristics are not so pronounced.

Many of the soils of the tropical highlands are derived from igneous rocks. The mineral salts are released by weathering under warm and humid conditions. Where the bedrock consists of basic rocks, such as lavas and intrusives, the resulting soil is reddish in color and relatively fertile Soils developed from acidic rocks are usually less richly colored and not so productive. It is a noteworthy fact that the most extensive and successful coffee plantations supplying most of the world's commercial coffee are located on the reddish soils of tropical highlands. The red soils of Brazil are classical examples of this fact.

On the whole, the soils of the tropical highlands resemble those of the humid savannas but are generally less leached, more readily tilled, and more productive The application of commercial fertilizers is necessary except where active weathering serves to furnish the soluble minerals essential for plant growth

Tropical significance.—The tropical highlands are, on the whole, rather pleasant places in which to live Temperatures are moderate, characterized by a diurnal rhythm which does much to relieve the monotony of small seasonal changes. Nights are usually cool enough to be quite invigorating The winds, though neither dangerous nor disagreeable, are strong enough to give a desirable freshness to the atmosphere. The rainfall, from 30 to 60 inches per year in most parts, is sufficient for abundant plant growth, and its seasonal distribution is conducive to well defined periods of tilling the land and harvesting the crops.

Both grain and cattle production are actively carried on in many areas, and further expansion seems assured Maize is quite generally grown, sorghums and millets are important in Africa, and the production of small grains varying from wheat to barley is common practice The cattle industry on the highlands of Africa and Brazil has met with conspicuous success, although some places are so remote from markets that only the hides have commercial value. These phases of agriculture bear close resemblance to the practices of the middle latitudes, a fact accounted for by the altitude of the tropical highlands As a result, these areas are perhaps the best "white man's lands" in the warm zone, but they are handicapped economically in that their products must compete with similar products raised nearer the great world markets. The one outstanding exception to this general statement is coffee production, and for this reason the tropical highlands are sometimes spoken of as the world's coffee lands.

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CHAPTER XVII

Economic Products of the Tropical Humid Regions

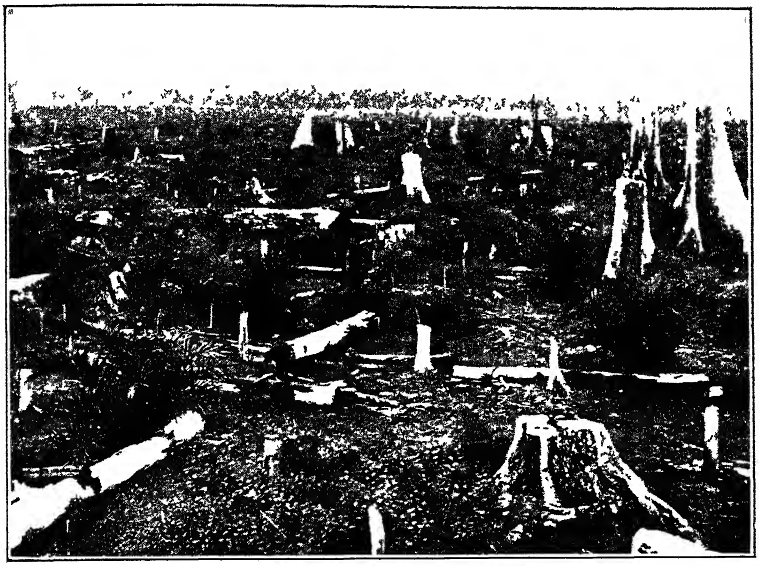
FOR many centuries the tropical humid regions were of importance to the western world mostly as sources of various luxury articles, among which spices ranked high. When ships were small and traffic on land and sea was slow and hazardous, the only products which could stand the high cost of transportation and the long delays involved were those of small bulk, high value, and excellent keeping quality.

Commercial agriculture in the humid tropics was made possible by the development of steamships for ocean traffic, a development which has come during the past century Now these regions supply many raw materials and foodstuffs which must be considered indispensable to the industrialized regions of the temperate zones In turn, the tropical lands depend upon the middle latitudes for the products of modern industry. All tropical countries are at present purely agrarian in character That the majority of them are politically dependent upon highly industrialized mother countries has been and is yet a factor in their retarded industrial development British India is the only such country with a modern, well developed industrial region the Bombay district Everywhere else industrialization is mostly associated directly with the products of the soil, as, for example, the manufacture of sugar in Java and Cuba.

Among the many products of the tropical regions, bananas, cacao, coconuts, and rubber are typical for the rainy tropics Of somewhat less prominence are spices, medicinal materials, and cabinet woods Sugar cane is grown in both the rainy tropics and the regions with a savanna climate, while coffee is produced on tropical uplands

Because of climatic conditions most of the products characteristic of the tropics cannot be grown elsewhere This is particularly true of bananas, cacao, and coconuts Some others, as for example sugar, are not limited to the tropics, but the costs are materially higher when production is attempted outside the areas of optimum natural conditions.

Thus the humid tropics during the past half century have become an integral part of world economy, and in the future,



Courtesy, Algemeen Proefstation der A V R O S, Medan, Netherland India

Fig. 181.—A cleared tropical rainforest in Sumatra. Note common practice of leaving large stumps and fallen trunks to decay in the field. Young plantation of oil palms.

as the population of the earth grows, they are bound to play a role of increasing importance as purveyors of foodstuffs and raw materials for the areas of dense population farther poleward. Even now, anything which might prevent or seriously impede the exchange of products between the lower and the middle latitudes would precipitate a major economic catastrophe, the consequences of which no civilized country could escape

THE BANANA

The banana has long been a staple food of the people in the humid tropics In the United States the sweet banana is so common on the fruit stands as to lead people to believe that is the only kind grown; they are surprised, therefore, to learn that in the tropics there are hundreds of varieties, differing greatly as to size, color, flavor, and uses. Some bananas are large, others small; some are red, others light tan to deep yellow; some are sweet and edible when ripe, while others are starchy and must be cooked or roasted before they can be eaten. Some kinds are grown for their fleshy, edible rootstocks, others for the palatable stems of their leaves Some of the Oriental varieties are especially rich in starch, and therefore are used for meal. A small, pear-shaped variety is valuable principally as a dried fruit. Another variety is used as a source for banana oil and is entirely unfit to eat. Still other species are valuable for the fibers obtainable from their leaf stalks, this being particularly true of *Musa textilis,* the plant which is widely known as the source for Manila hemp.

The large number of varieties makes the banana of paramount importance in the sustenance agriculture of the tropics. The plant, by its fruit or its roots, furnishes food, and by its leaves and fibers provides materials for shelter and even for some forms of clothing adapted to tropical conditions.

Climate and soil conditions.—Bananas require abundant moisture, sunshine, and all-year warmth The banana plant makes enormous demands for water, and therefore it is most successfully grown where a rainfall of 80 to 200 inches is well distributed throughout the year In some places where the rainfall is deficient during part of the year, irrigation is practiced, but that is possible only where an ample water supply is available. In addition to their heavy water requirements, bananas demand fertile, friable, and well aerated soils.

The banana plant will endure temperatures as low as 48°F., but the optimum is much higher, about 75 to 85°F. Wind is another factor of importance. While the plant can stand fairly

strong winds during its growing period a blow of 20 miles an hour may prove disastrous when the fruit is maturing.

Principal commercial species of bananas.—From a commercial standpoint the most important species of banana is *Musa sapientum* The species presumably was native in the tropical lands of the Far East but was brought early to the Western Hemisphere and is now found growing in the humid lowlands throughout the rainy tropics. The principal variety is known as *Gros Michel,* the fruit of which is large, well-flavored, and capable of standing shipment—qualities which give it commercial leadership A less popular variety is the red or claret banana, known also as *Baracoa* and *Red Jamaica.* The fruit is shorter and stubbier than that of the Gros Michel, and the bunches are usually somewhat smaller; the flavor is deemed to be superior by some, while others do not care for it

Photo by N A B

Fig. 182.—Banana trees with bunches of fruit near maturity. Note that the individual bananas, the "fingers," point upward from the stem.

Another species of the same family is the *Musa paradisiaca*—Fruit of Paradise—more commonly called the plantain or platano It is in common use in the low warm countries of the Torrid Zone as a general substitute for potatoes.

The Banana plantation—early stages of growth.—The banana is propagated from rhizomes and suckers. Plantations are first set with pieces of rhizome or rootstock, called *bits,* selected from vigorous, healthy plants. In Central America the

common practice is to set these bits in rows, 18 to 24 feet apart each way. The bits weigh from three to four pounds each, and in preparing them care must be taken that each contains at least one "eye"[1]

The later work in the plantation is *cleaning,* which consists of cutting away with a machete the ever luxuriant weeds and undergrowth. During the life of the plantation, cleaning must ordinarily be done three to five times a year

A period of 11 to 14 months is necessary for the banana tree to attain maturity and develop its blossom, at which time it reaches a height of from 16 to 30 feet, depending on soil and weather conditions. Three or four more months are necessary for the development of the fruit to the point where it is ready for cutting It thus takes from 14 to 18 months after planting before the first crop is ready, and that crop is usually of little value because the root systems have not been developed sufficiently to provide for the full sized bunches of large, plump fruit demanded by the trade. But while the mother plant is maturing its bunch of fruit, young sprouts known as *suckers* make their appearance. Soon after the fruit, the "bunch of bananas," has been gathered, the stem of the plant is cut down. The suckers are then removed from the inner side of the basal stem and only a limited number allowed to develop along the outer edge. After several years, as the plantation ages, the original single plant becomes succeeded by a sort of circular hill or *mat.* In most regions profitable returns are not expected within two years after the first planting. After that, production is virtually continuous during the life of the plantation, a period varying in different regions from 5 to 15 years, or even longer. Each tree bears but one bunch or stem of fruit Soon after the harvest the stalk is cut down to make place for new growth.

Harvesting and marketing.—The harvesting and marketing processes, as operated by the major fruit companies, approach perfection in coördination of industrial technique. As the incoming ship approaches the port, wireless instructions

[1] The "eye" is the embryo plant

are sent from the company headquarters to the local managers notifying them as to the number of stems desired, the exact hours for loading, and the destination of the cargo The local managers then instruct the superintendents of the banana farms by telephone as to the number of stems each is to supply and for what market the cargo is destined. The probable number of days which will elapse from the day of cutting until the fruit reaches consumption centers is estimated; cutters are advised accordingly, and orders issued timing the work so that the fruit is delivered and the cars loaded at the railroad sidings but an hour or two before the engine comes along to make up its train for the trip to the port. The railroad trip may be 10 miles or it may be 60, but the work is so integrated that the loading of the 40 to 80 thousand stem cargo is accomplished in from 8 to 12 hours without congestion or confusion. The clocklike precision with which these processes of harvesting and transportation are carried on is necessitated by the climatic conditions and by the perishable nature of the fruit.

International trade.—The importance of the banana as a staple foodstuff in the rainy tropics has been recognized for centuries, but until modern methods of transportation were developed, the perishable nature of the fruit limited its consumption to areas near the centers of production. Swift, well ventilated steamships now provide the connecting link between producers in the tropics and the consumers in the cooler climates, and they have made possible the organization of the banana industry into one of the greatest commercial enterprises of the times

Banana imports from Cuba into the United States began early in the nineteenth century, but regular shipments were not made until after the Civil War. Production on a large scale was undertaken after 1870 in Panama, Costa Rica, and Jamaica. Prior to 1899 banana shipments were handled by small companies, competition was keen, and losses were common. The natives were encouraged to produce the bananas, but the so-called fruit companies were only the transporting and marketing agencies

Local production by unsupervised natives failed to provide a supply of fruit dependable both as to quantity and quality, and it soon became evident to leaders in the commercial banana industry that success could be attained only through coördination of production, harvesting, transportation, and marketing processes. At the turn of the century, great corporations were organized on that basis, and since then the industry has become a huge, integrated business involving complete coördination of all processes from the planting of the "bit" in the tropical low-

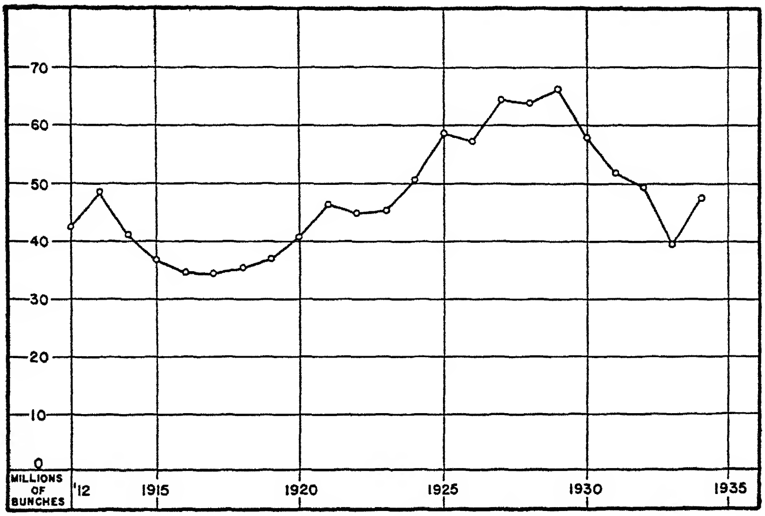


Fig 183 —Banana imports of the United States. (Source of data J T Palmer, "The Banana in Caribbean trade," *Economic Geography*, Vol. VIII (1832), and *Commerce and Navigation of the U S A*)

land to the delivery of the ripened fruit to the retailers in American and European cities.

The greatest centers of commercial banana production lie along the coast of the Caribbean and on the islands of the West Indies. During the past decade, Honduras has consistently held first place in banana exports The United States ranks as the foremost market, a position readily attributable to its large population, the generally high standards of living, and nearness to regions where high quality bananas can be produced cheaply.

Bananas are marketed in every country in North America and Europe. This nourishing and delectable fruit from the tropics is welcomed in the shops and markets of Alaska, Iceland, and even of far-off Spitzbergen, almost next door neighbor to the North Pole!

The success which has marked this development has often been referred to as a "most glorious romance of the Tropics," or in other terms equally sentimental, but after all it is fun-

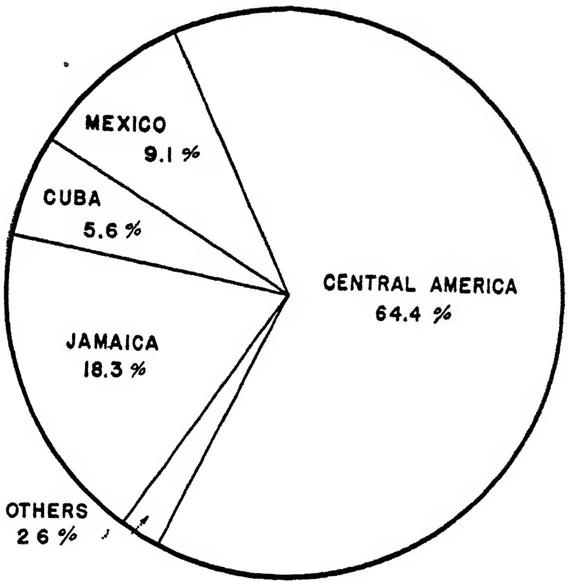


Fig. 184.—Countries of origin of bananas imported into the United States, average 1928-1932. (Source of data: *Commerce and Navigation of the U. S. A.*)

damentally a correlation of production and transportation to meet market demands, made possible by rapid means of transport. It took much more than romance to blaze the trail and work out the sure avenue of success in a phase of agriculture which had not been looked upon as having any commercial possibilities. Keen vision, daring but sound business methods, intelligent experimentation, and careful organization were and are still the essential factors of success.

CACAO

Cacao is one of the crops most typical of the rainy equatorial belt. The cacao tree (Theobroma cacao, *Theobroma*=food of the Gods) finds its optimum natural habitat in the rain forest, and hence its successful cultivation requires similar conditions. The average temperature should be at least 75°F., and minimum temperatures should never fall below 60°F. As a result of these rather rigid requirements the tree is restricted to the tropical lowland areas, and only rarely is it cultivated on a commercial scale at altitudes above 1,500 feet. High humidity, ranging between 80 and 90, and heavy rainfall, 50 inches or

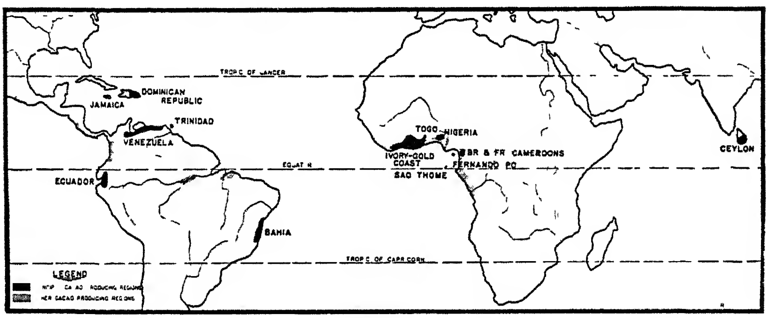


Fig. 185 —Principal cacao producing regions of the world

more per year, are essential. Strong winds are harmful because they stimulate evaporation, while the existence of a pronounced dry season, even of short duration, precludes commercial success. In many regions it has been found advantageous to provide shade by interplanting other, taller, trees in order to prevent excessive evaporation

Thus, the commercial production of cacao necessarily centers in areas of damp, warm climate, of continual mugginess, unhealthy for native as well as for white Such a climate not only is inimical to man, but also to the plants he has domesticated, and cacao, an easy prey for many tropical pests and diseases, has probably suffered more than any other tropical crop.

Cacao production.—The cacao tree is a native of tropical America and was held in high esteem by the ancient Mexicans,

who used the roasted beans, together with corn and pimento, in the preparation of a dish called "chocolatl" Although introduced into Europe by the Spaniards early in the sixteenth century, cacao did not become popular until late in the eighteenth century. The rapid increase in consumption during recent decades is due to the production of cheaper sugar and a general rise in the standards of living.

Since the cacao tree blooms continuously, it always carries some ripe fruit Usually, however, there are one or two principal harvests during the year The fruit is a pod which contains

FIG. 186.—Picking cacao pods. Plantation in Ecuador. Note pods attached to trunks of trees. Women in foreground are shelling the cacao beans from the pods.

a number of seeds, the cacao beans. These beans not only have high nutritive value, but also are mildly stimulating because of their content of theobromine, an alkaloid related to caffeine. The beans are subjected to a fermentation process, then dried. After this they are ready for shipment

In preparation for consumption the beans are cleaned, dried, and roasted Chocolate is produced by adding some sugar to the finely ground beans Cocoa is made by eliminating most of the vegetable fat, the so-called cocoa butter. The latter is in great demand for the preparation of cosmetics.

Distribution.—Tropical South America and the West Indies were for centuries the world's main source of supply of cacao. In the latter part of the nineteenth century a new area of production began to develop in Africa, first on the islands in the Gulf of Guinea, and later on the Guinea coast itself. By 1920 this area had definitely outstripped the old centers of production in the Western Hemisphere.

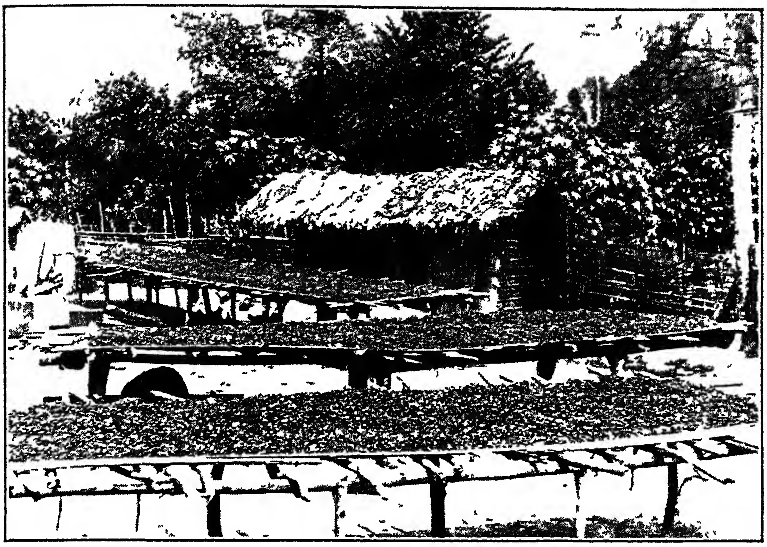
Most of the cacao which enters world trade is derived from either of two groups of varieties of the cacao tree, the *Criollo* or the *Forastero*. The Criollo type furnishes a cacao of superior grade, which is in great demand for blending purposes, but the tree gives rather low yields and shows little resistance against disease. The bulk of the world's cacao crop is produced by the Forastero group. The trees are quite hardy and yield well, but their product has an aroma decidedly inferior to that of the Criollo. Thus, while tropical Africa, which grows the Forastero, at present produces larger quantities of cacao, the better qualities continue to come from tropical America, especially from those districts where the plantations consist of trees of the Criollo type.

In Africa the cacao plantations are mostly in the hands of the natives, with only a minor percentage of European estates. They are located in the belt of equatorial rain forests which skirts the Gulf of Guinea from southern Sierra Leone to beyond the mouth of the Congo river. The principal center of production is the Gold Coast, the source of about two-fifths of the worlds' cacao crop.

Along the coast of Nigeria the cacao industry is steadily increasing in importance, and sufficient land is available for considerable expansion. The French have established an important cacao industry along the Ivory Coast, the bulk of the output being shipped to France. Producers of lesser importance are Togo and the islands of Saint Thomas, Principe and Fernanpo; the cacao of the former two islands is sold through Lisbon, while the product of the third is exported chiefly to Spain.

In America the principal centers of production are much more scattered. The newest and at the same time the most im-

portant producer is the state of Bahia, Brazil The cacao is grown on the river flats and lower hills of the coastal strip, where temperatures are high and where the southeast trade winds provide an abundance of precipitation. Brazilian cacao is comparable in quality with that from the Gold Coast and brings only slightly higher prices. Another important producer of ordinary cacao is the Dominican Republic.



Courtesy, Department of Agriculture, Gold Coast Colony Photo by J A C Holm

Fig. 187.—Drying of cacao beans in the Gold Coast Colony, Africa.

Superior grades of cacao are exported by Trinidad, Venezuela, and Ecuador. In Venezuela the majority of the cacao plantations are located in the narrow coastal strip east of Puerto Cabello and in the region around the southern end of Lake Maracaibo, while in Ecuador the cacao industry centers in the valleys north of Guayaquil Ecuador once was the world's principal cacao producer. With the expansion in other areas the country lost its predominance, and in recent years the advent of one of the most dreaded cacao diseases has threatened the industry with total annihilation Other producers of some importance are Colombia, Costa Rica, and Jamaica.

International trade.—The cacao that enters world trade goes almost entirely to the countries of Europe and North America, the United States alone taking nearly two-fifths of the total. Most of the United States' imports of cacao beans are from the Western Hemisphere, especially from Brazil, the Dominican Republic, Trinidad, and Ecuador, but during the past decade Africa's share has been steadily mounting. The chief competitors of the United States in the purchasing market are Germany, Great Britain, the Netherlands, and Switzer-

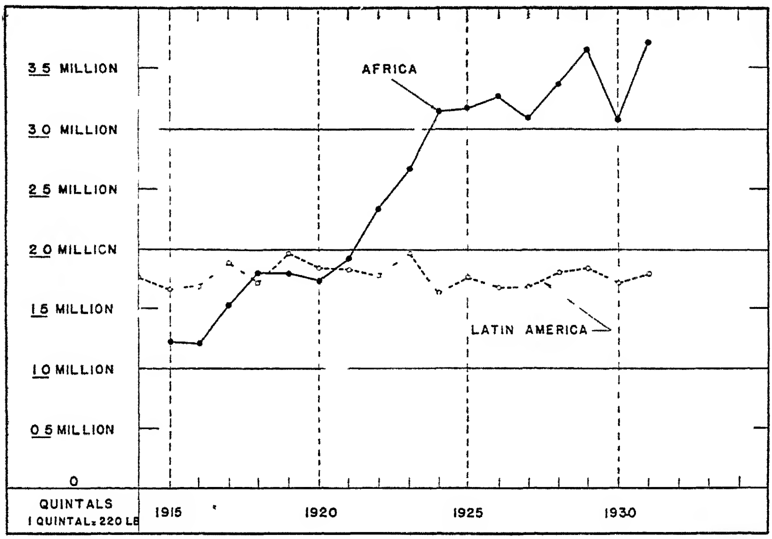


FIG 188.—Annual exports of cacao of Latin American and of African countries since 1914. (Source of data *International Year Book of Agricultural Statistics*, International Institute of Agriculture, Rome)

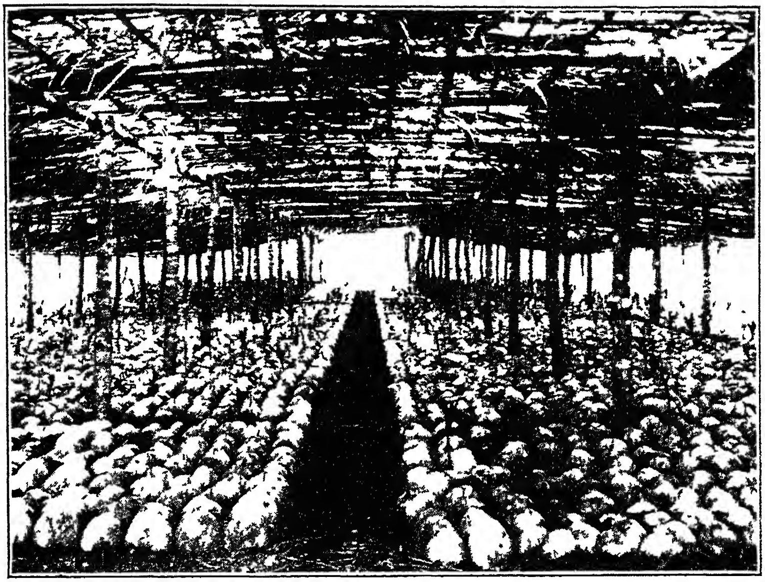
land. The Netherlands have a highly developed cacao industry and export considerable quantities of cocoa, cocoa butter, and chocolate. Switzerland is principally an exporter of chocolate and chocolate products.

COCONUT AND OIL PALMS

One of the plants indispensable to primitive native economy in many parts of the warm humid regions is the coconut palm. Its products are so diversified that a small grove suffices to as-

sure tropical man of all he needs for survival: food and drink, implements, shelter, and a little clothing During recent decades, however, the importance of the coconut palm has extended far beyond the tropical lands; its fruit has become one of the principal sources of vegetable fats for the inhabitants of the industrialized temperate regions.

The coconut palm.—The coconut palm (Cocos nucifera) is a true child of the tropics it requires much sunshine and continuous warmth Although it can stand brief periods of tem-



Courtesy, Departement van Landbouw, Netherland India

Fig. 189.—A coconut nursery. Coconuts are imbedded in moist sand. Note young sprouts growing through the husks.

peratures as low as 60°F, it does not thrive well where average annual temperatures are below 75°F. High humidity and high annual precipitation, preferably over 80 inches per year, are essential, periods of drought having an unfavorable influence both on the palm itself and on its production of nuts While the outermost limits of its distribution lie between 26° N latitude and 22° S latitude, the areas with climates favorable for commercial production do not reach much farther than about 20 degrees on either side of the Equator

Although the coconut palm grows fairly well in a variety of soils, it thrives best where soils are loose, sandy, and well drained Standing water is detrimental to the plant. A rather unusual feature of the coconut palm is its high tolerance for saline soil moisture; even distinctly salty water causes no harm.

There is a native saying that the coconut palm needs the sound of the human voice to thrive. One might add that it also needs the voice of the sea: it is an inhabitant of the coasts of the tropics. It occurs on the little atolls of the Pacific, which rise out of the ocean as so many groves of palm trees; it fringes nearly all the humid shores of the islands and mainlands within the low latitudes. The coconut palm begins to bear fruit from 8 to 10 years after planting, often reaches a height of more than 80 feet, and may live to be a hundred years old The fruit consists of an outer fibrous cover enclosing a hard, woody nut lined with "meat." This meat is valuable commercially because of its high content of vegetable oil. Not only is this oil an excellent soap stock, but its chemical composition is so closely akin to that of butter that, after refining and deodorizing, it can be made into high quality oleomargarine

Commercial production.—After the fruit is gathered, the outer husk is removed and the nut split open. Then it is dried in the sun, over a fire, or, in a few cases, with the aid of modern drying apparatus. As a result of this process the meat loosens from the hard shell, which is discarded. The dry product, *copra,* contains 50 to 60 per cent of oil and thus is a relatively concentrated commodity Sometimes the extraction of the oil takes place in or near the areas of production; more often, though, the copra is shipped long distances to the centers of consumption in the temperate zone

The centers of commercial coconut production are Netherland India,[2] the Philippines, Ceylon, the islands of the western Pacific, and British Malaya. In the Philippines the industry is concentrated in the eastern and southeastern sections of the is-

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[2] "Netherland India" is the official designation for the islands commonly referred to as the Dutch East Indies

lands, where rainfall is high and where there is no prolonged dry season. The industry is strongly dependent upon the American market Large quantities of copra are shipped to the Pacific ports of the United States, especially to San Francisco, where an important oil crushing industry exists. Smaller quantities are sent directly to Atlantic ports An important oil crushing industry has developed in Manila, the only center in any of the producing areas where the oil is extracted on a large scale basis. Because of the favorable economic and political connections, the oil is exported directly to the United States. With such changed political relations as will come with Phil-

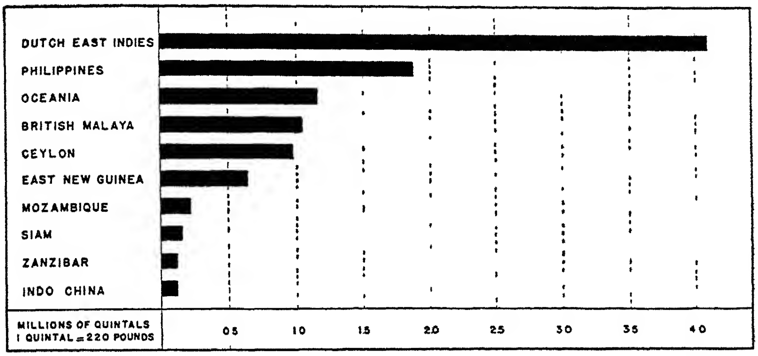


FIG. 190.—Exports of copra by principal producing countries of the world. Average 1928-1931. (Source of data *International Year Book of Agricultural Statistics*, International Institute of Agriculture, Rome)

ippine independence, there are grave possibilities that this trade may be adversely affected.

In Netherland India the commercial coconut industry is of greatest importance in the sparsely populated Outer Provinces, especially in Celebes, Western Borneo, Sumatra, and the Moluccas. The exports are sent mostly to European markets

In all producing areas the coconut industry is primarily a native industry; western capital is only directly interested in it to a minor degree. This is because copra is essentially a mass product and not an article where quality counts heavily. Furthermore, the growing of coconut palms does not require a knowledge of specialized agriculture, thus making it an econ-

omic activity par excellence for the natives, who can sell their copra when prices are favorable or can wholly or partially withdraw from the market when prices are low.

The principal centers of consumption of copra and coconut oil lie in western Europe and the United States. In this country most of the oil is used for various technical purposes. such as the manufacture of soap and other toilet necessities. In Europe, on the other hand, much of it goes into the manufacture of margarine, the cheap butter substitute of the densely populated, highly industrialized countries

The only other coconut products of commercial value are the shredded, desiccated meat, and the fiber of the outer husk. The former belongs in the luxury class and is used mostly in cakes, pastries, and confectionery. The latter enters the trade under the name of *coir* It is used in the Orient for the manufacture of rope and other cordage, and it serves in Europe for the manufacture of coarse but strong matting. To a slight extent it is used in the United States for the manufacture of doormats.

Whole coconuts are not of great importance in international trade because they are too bulky and of too low value to stand long distance transportation The food market in the United States is provided with nuts mainly from the nearby Caribbean lands.

Oil palm.—The African oil palm (Elaeis guineensis) is a competitor of the coconut in the markets for vegetable fats in the middle latitudes. Like the coconut palm, the tree requires equatorial conditions· its native habitat is the tropical rainforests of the Guinea coast and the Congo basin. It thrives best at the edge of the forest or in less dense sections where sunshine and light are plentiful It needs high humidity and a rainfall of over 80 inches It cannot stand a prolonged dry season. The fruit of the oil palm is small, from one to two inches in diameter, yellowish white, and grows in bunches which may contain as many as 1,000 to 1,500 each. It consists of a soft yellow pericarp and a hard kernel, of which the former contains the palm oil proper, the latter the palm kernel oil.

In Africa the trees are found scattered through the forests of the low, damp coastal areas and interior basins, and from time immemorial they have furnished the negro with a food and an unguent. In clearing the jungle the natives have generally left the oil palms standing. Protected by the negro farmer, these palms have multiplied until in many regions they have developed into solid groves. Oil palm forests are especially extensive

Courtesy, Algemeen Proefstation der A V R O S, Medan, Netherland India

Fig. 191.—Harvesting bunches of fruit of oil palm on plantation in Sumatra.

in the moist coastal lands of Nigeria and Dahomey, and a belt in which they are common stretches westward along the entire Guinea coast, as far as the French colony of Senegal Toward the south, oil palms are plentiful in the Cameroons, the Congo, and Angola.

The oil is pressed from the pericarp with the aid of primitive native equipment, often simply by means of treading. While

much of the oil is used locally, a large surplus is available for export. The hard kernels keep well, contain about 45 per cent of oil, and are shipped mostly to countries in the North Temperate Zone. Among the West African countries, Nigeria and Sierra Leone depend almost entirely on the exports of oil and kernels for their revenues.

In Africa the processes of oil production are primitive, and transportation often is slow and difficult. Much of the oil so produced is of such low quality that it can be used only for ordinary soap stock.

In recent years extensive plantations of oil palms have been established under western management in Netherland India (Sumatra) and British Malaya. This new plantation industry has proved to be a dangerous competitor of the African industry. The oil produced on the estates is more carefully prepared than native oil can ever be. It has a low free fatty acid content and is, therefore, in great demand.

The centers of consumption of palm oil are western Europe and the United States. In addition to the oil from Africa (mainly from Nigeria and the Belgian Congo), the United States is importing increasing quantities of estate-produced oil from Sumatra Most of the palm kernels are shipped to Europe, where the oil is manufactured and used in the margarine industry.

RUBBER

One of the most spectacular developments of the twentieth century is the growth of the rubber industry from a primitive gathering activity, carried on by semi-savages in the equatorial rainforests, into one of the most important plantation industries of the tropics.

Rubber-like substances are known to exist in many plants of the temperate as well as of the tropical regions. Thus far, however, the largest and most satisfactory rubber producing plants have been found in warm regions where rainfall and humidity are high throughout the year Among the numerous actual or potential producers, the Hevea tree (Hevea brasiliensis) has

attained preëminence because of its high yields and the excellent quality of its rubber The bark of this tree yields a ready flow of latex, a milky juice not unlike that of the American milkweed. Upon treatment with smoke or with weak acids the rubber contained in the latex coagulates, and then it is either made into balls or into thin, crepe-like sheets.

The Hevea grows wild in the extensive tropical forests of the upper and southern Amazon basin, where the latex was known to the Indians under the name of "Cahuchu" (wood tears) and was used by them to weatherproof their moccasins. Cahuchu, or caoutchouc, became known in Europe about the middle of the eighteenth century, and for more than a hundred years the commercial value of the product was based mostly upon its property of erasing pencil marks ("rubber"). Although the invention of the vulcanization process by Charles Goodyear in 1839 paved the way for large scale use, rubber did not become of major industrial importance until the rapidly developing bicycle and automobile industries created an enormous demand for it With a large part of the civilized world riding on pneumatic tires, rubber has become one of the raw materials indispensable to our present industrial age.

Change from wild rubber to plantations.—The inhospitable tropical environment and the scattered distribution of the trees through the forest proved to be great handicaps in the exploitation of the wild rubber resources of the Amazon basin. It soon became evident that the supply of wild rubber was not sufficient to satisfy the ever-increasing demands. During the latter period of the nineteenth century, efforts were made to introduce the Hevea in other parts of the world and to cultivate it in plantations These attempts were entirely successful, and at present more than 95 per cent of the world production of rubber is derived from trees planted elsewhere, while the wild rubber output of Brazil has fallen to a negligible percentage.

The Hevea tree requires a truly tropical environment, with continuous warmth, much rainfall, and high humidity; a pronounced dry season is decidedly unfavorable, because it interrupts the flow of latex. Although the Hevea grows on lean as

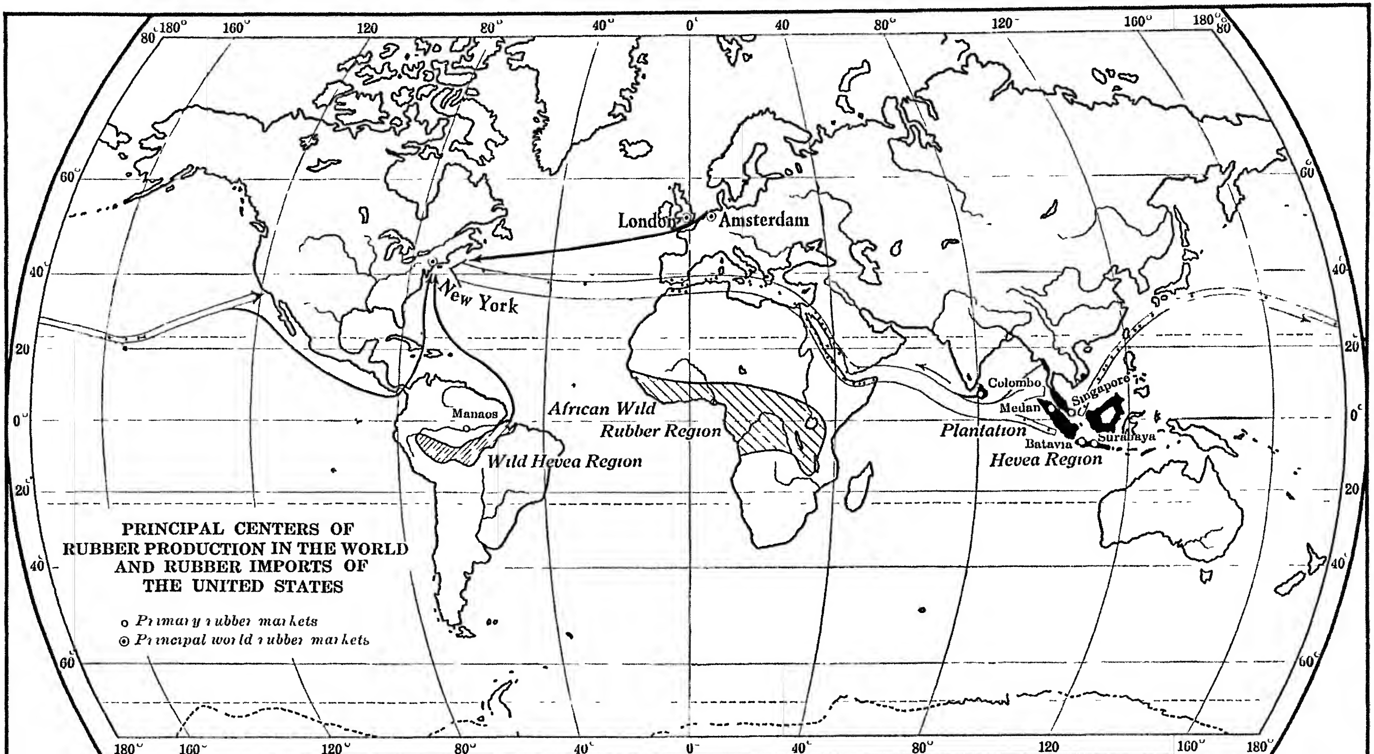
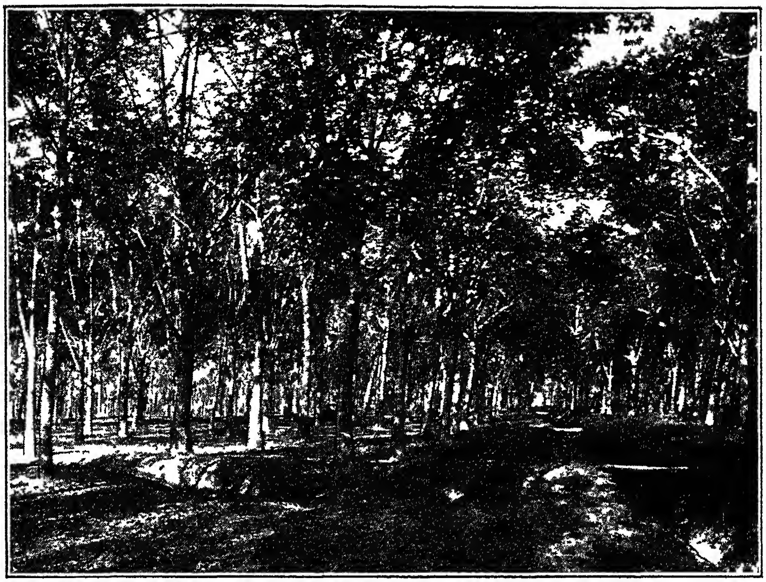


Fig. 192.—Principal centers of rubber production in the world and rubber imports of the United States. (Projection after McKnight and McKnight.)

well as on fertile soils, its warmth and moisture requirements are such that it can be grown only within the belt of the rainy tropics.

Labor needs.—The tapping of the trees is not only a laborious task, but one which requires considerable skill. In order to have each tree tapped every other day, an abundant supply of low priced labor is a necessity. Hence, plantations have been successful only in those sections of the Far East where an ample



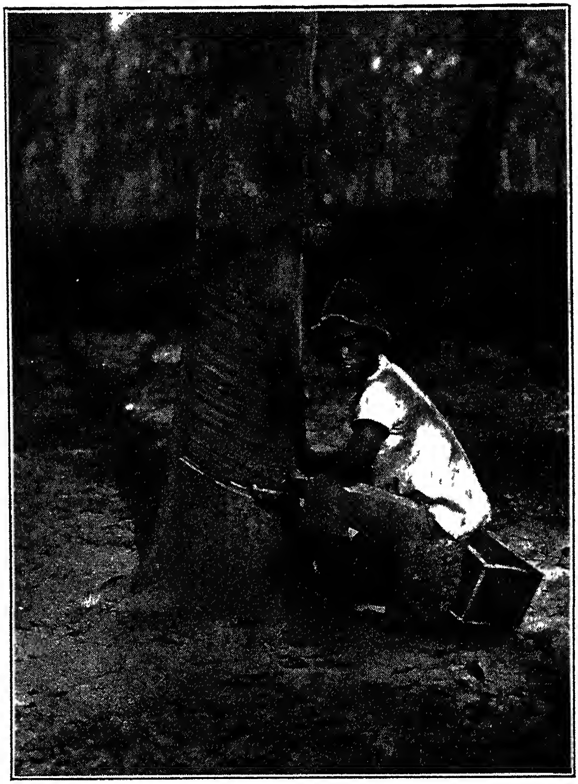
Courtesy, Algemeen Proefstation der A V R O S, Medan, Netherland India

Fig. 193.—Mature plantation of rubber trees in Sumatra. Note diagonal marks of tapping on the tree trunks.

supply of cheap labor is available or can readily be introduced. Thus, British Malaya and Netherland India have become the largest rubber producers in the world

Rubber plantations in the Far East.—In British Malaya the plantations are found mostly on the low coastal plains; a few are in the hilly belt farther inland Climatic conditions are ideal, but much of the labor is imported, mostly Tamils from British India and Chinese from southern China.

In Netherland India rubber is produced over the entire western part of the archipelago Modern rubber estates involving heavy investments of French, English, and American, as well as of Dutch, capital exist in Java and Sumatra. In various parts of the islands the natives have followed the example of western



Courtesy, Algemeen Proefstation der A V R O S, Medan, Netherland India

Fig 194.—Tapping a rubber tree in Sumatra. Note thin slice of bark laborer is removing and cup which will be placed so as to catch the flowing latex. The number of tappings indicated by the amount of bark removed.

capital and have planted large areas to rubber trees. The product of these plantings, the so-called "native rubber," has in recent years become an important factor on the world market. The native producer has few overhead expenses, in some instances none at all He does not need to worry about the labor

problem, since usually the members of his own family and a few immediate friends do all the work; he does not have above him a board of directors, and shareholders, clamoring for dividends. Thus, he can tap his trees whenever prices are favorable and when the market goes down he can discontinue tapping without incurring serious losses. Quite true, the rubber he produces is of an inferior quality, and its color is muddy and unattractive in comparison with the beautiful creamy white sheets produced by the European plantations. Nevertheless, it brings only slightly lower prices

This native competition raises a serious question for the plantation rubber industry. After all, rubber is only a raw material of industry, and it does not need the extreme care given to it on the estates. The Hevea is a quite hardy tree; it seems to be able to stand considerable abuse, and it lends itself very well to the rather shiftless methods of native cultivation. It is possible, therefore, that in the rubber, as in the coconut industry, the largest share of the world production may eventually be contributed by native growers.

Considerable quantities of rubber are produced also in Ceylon, British Borneo, southwestern Siam, and in French Indo-China and British India. The two countries last named are handicapped by the existence of a pronounced dry season. Furthermore, attempts are now being made to produce Hevea rubber on plantations in Liberia on the west coast of Africa, at Fordlandia in the Lower Amazon Valley, and in the Philippines. In all these areas the labor supply seems to be the problem most difficult to solve

Some wild Hevea rubber from the Amazon basin still reaches world markets. This is the so-called Para rubber, a highly esteemed, smoked rubber prepared according to the old laborious processes of Brazilian native tappers.

Among the numerous other kinds of rubber, most of which are of little commercial importance, should be enumerated the *ceara* (from Manihot glaziovii), produced in northeast Brazil; the *castilloa* (from Castilloa elastica), produced in southern Mexico, Central America, and northern South America; and

the *ficus* (from Ficus elastica), produced in the Far East *Guayule* (Parthenium argentatum), a bush of the dry regions of Mexico, is one of the important potential producers of rubber, and goldenrod is also considered to be a possible source

In all modern countries rubber is used in large quantities and for many purposes. The United States, with its huge production of automobiles, is by far the most important consumer of rubber, the bulk of which is used for the manufacture of tires. The city of Akron, Ohio, is the principal center of the rubber manufacturing industry.

SUGAR CANE

The sugar cane is the oldest and has long been the most important source of sugar for human consumption. To be sure, all through ancient and medieval ages the sweet tooth of the population of the Occident had to be satisfied with honey and the juice of birch or maple, and not until recent times did sugar as such become known to the western world.

The sugar cane (Saccharum officinarum) is a native of southern Asia, probably of British India, where it was known in earliest times From there cultivation spread eastward as far as southern China, but only slowly did the knowledge of the existence of this valuable plant filter through to the west The slowness of the movement westward was due partly to the fact that the primitive brown sugar commonly made in India had rather poor keeping qualities and thus was not so well suited for caravan trade as were silks and spices

During the later Middle Ages, sugar cane was grown in the countries around the Mediterranean, but climatic conditions were not favorable enough to induce any large scale development of the sugar industry there. From the Mediterranean, however, the crop spread rapidly westward, first to the islands off the African coast, thence to the newly discovered American continents, where a flourishing industry, based primarily upon imported black slave labor, became established in the Antilles and Brazil As a result of this development, cane sugar ceased to be a luxury and became an article of common consumption.

Climate conditions.—Although some varieties of sugar cane ripen within a period of about eight months, most of them require a long growing season, from 12 months to as many as 24. Since frost is detrimental to cane, the cultivation of this crop is generally limited to the frost-free areas of the world. Furthermore, the continuous high temperatures which the plant requires, above 70°F. and preferably around 80° to 85°F., restrict successful cultivation to the warmer parts of the earth.

During the growth of the cane an abundant supply of moisture is essential, either as rain or, better still, by irrigation. A combination of much sunshine and a damp tropical atmosphere is most favorable for the development of thick, tall cane, rich in sugar. During the period of ripening of the cane dry weather is essential—heavy rains during this critical period lead to an appreciable dilution of the juice, and hence to a lower percentage of sugar. Sugar cane, therefore, cannot be cultivated successfully in the permanently wet tropics, as for example in the Amazon or the Congo basins. The world's commercial plantations are confined principally to frost-free lands where the annual precipitation is at least 50 inches and where there is a short dry season.

In both hemispheres, but more especially in the Northern, sugar cane reaches well into the subtropics, as in northern India and southern China. There the shorter growing season results in cane of smaller size and lower sugar content than is characteristic of the truly tropical varieties.

Production and distribution.—In the commercial production of cane sugar one of the principal difficulties to be met is the fact that cane is a raw material of great bulk, and during a brief harvesting season huge quantities must be transported quickly to a central crushing plant. This tends to limit commercial production of sugar cane to lowland areas, where transportation is easy. It also favors the cultivation of sugar cane on large plantations, instead of on scattered holdings, because it is cheaper to establish efficient transportation systems. Such systems usually consist of a network of narrow gauge tracks over which small engines can draw long trains of heavily loaded

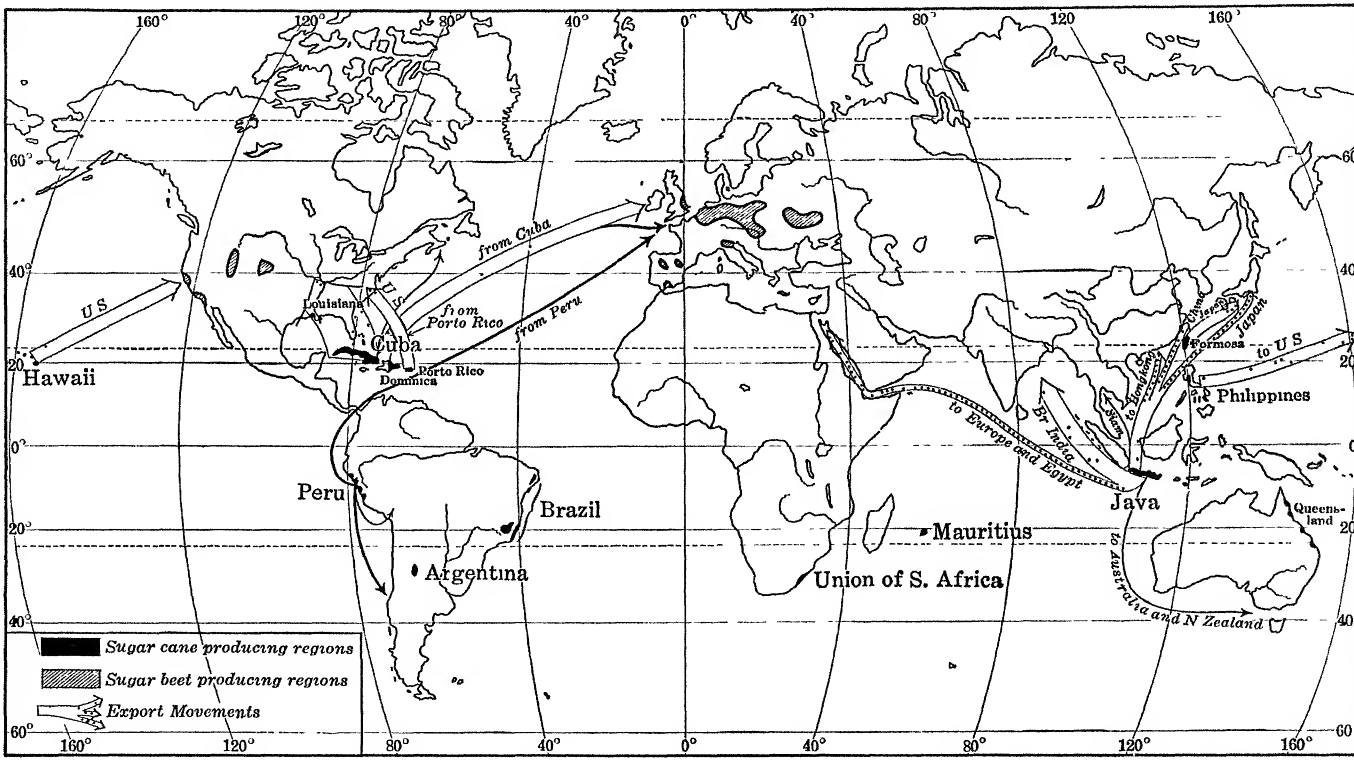


Fig. 195.—Principal centers of commercial production of sugar cane and international trade in cane sugar. (Projection after McKnight and McKnight)

cars. In many regions, however, much cane is grown by natives and sold to neighboring mills

The modern processes of sugar manufacture are rather complicated, and require costly machinery as well as a high degree of technical skill. The commercial manufacture of sugar is therefore largely in the hands of large corporations with ample capital at their disposal. In contrast to the rubber and copra industries, the sugar industry thus far has had little to fear from native competition.

Courtesy, Centrale Organisatie van de Suikerindustrie in Nederlandsch-Indie, Surabaya, Netherland India

Fig. 196.—Young Sugar Cane, Java. Narrow gauge railroad track and small engines are characteristic.

The two outstanding surplus producers of cane sugar are Cuba and Java. The conditions under which cane is grown in these two islands are vastly different

Except for the occasional occurrence of severe droughts, Cuba enjoys a climate which is ideal for sugar cane. Only from 12 to 15 months are required to mature the crop, and once the cane is in the ground the rootstocks continue for a number of years to send out new shoots, thus eliminating the cost of re-

planting the fields after the harvest is over. The soil is fertile, and good land is abundant and cheap. On the other hand, the population is rather sparse and labor is high priced. The cane farmers or "Colonos" who sell their cane to the numerous large mills give only indifferent care to their crops. As a result, the yields of sugar per unit of area are low.

Since Cuban independence the sugar industry has expanded rapidly because of the influx of American capital and the preferential tariff accorded by the United States to raw sugar im-

Courtesy, Centrale Organisatie van de Suikerindustrie in Nederlandsch-Indie, Surabaya, Netherland India

Fig 197.—Harvesting sugar cane by cutting and stripping. Bunches are loaded on small cars running on narrow gage railroad tracks.

ported from the island In recent years the industry has spread from the central provinces to the level lands of the east, but large areas are still available for future expansion The United States is the principal market, the sugar being exported raw to be refined in or near the North Atlantic ports, especially Philadelphia, New York, and Baltimore, or the Gulf port of New Orleans.

In Java, sugar cane can be grown successfully in the low coastal and interior plains of the central and eastern portions

India, the Far East, and Egypt Only small quantities of sugar from Java reach the European markets.

In addition to Cuba, among the producers of cane sugar in the Western Hemisphere should be mentioned Hawaii, Puerto Rico, the Dominican Republic, Brazil, Peru, and Argentina.

The Hawaiian islands have an oceanic climate with rather moderate temperatures, so that the cane requires a growing season of from 20 to 24 months. On the northeast or windward side of the islands precipitation is abundant, while on the dry leeward side the scanty rainfall must be supplemented by irrigation. The rugged topography of the islands has necessitated expensive engineering and construction works in developing plantations and providing essential transportation facilities As a result of an inadequate supply of native workers, much of the labor has been imported from various parts of the Orient Practically the entire Hawaiian export is sent to the United States, either to the refineries on the Pacific coast or to those on the Atlantic.

In Puerto Rico the sugar is produced in the low coastal plains, especially those of the north coast, and the surplus is exported principally to the United States. The Dominican sugar industry is concentrated in the low southern coastal plain. In South America, Peru is an important sugar producer. There the cane is grown in the valleys of numerous rivers which, on their way to the Pacific, cross the coastal desert Since there is virtually no rainfall, the plantations are all irrigated. In view of the limited quantity of available irrigation water and the competition of other crops, such as cotton, little further expansion of the sugar industry can be expected.

In continental United States, southern Louisiana has the distinction of being the only significant sugar cane district. Though important from a national point of view, it is of little consequence from the general standpoint of world supply.

Among the commercial producers of the Eastern Hemisphere mention should be made of the Philippines, Formosa, Queensland, Mauritius, and Natal.

In the Philippines, sugar has become an important crop be-

cause of its tariff preference on the American market; more than 95 per cent of the exports are sent to this country. The largest sugar estates are found on the islands of Negros, Cebu, Luzon, and Leyte

Mauritius and Formosa produce sugar chiefly for the export markets. The sugar industry of Australia is concentrated in the narrow eastern coastal plain of Queensland. The industry is noteworthy because Queensland is the only important producer within the tropics that uses white labor exclusively.

Important contributors to world production are British India and southern China. As far as the quantity of sugar produced is concerned, British India ranks in importance with Java and Cuba. Most of the sugar, however, is not refined but is consumed in the form of brown sugar, the so-called "gur," and practically no sugar is exported.

COFFEE

Of the numerous non-alchoholic beverages, coffee, tea, and cacao have attained leadership in volume of consumption Of the three, coffee ranks first in commercial importance The records indicate that more than 3,000,000,000 pounds of coffee beans are exported annually from the major producing countries, a convincing measure of the magnitude of this trade.

The use of coffee as a beverage probably originated on the plateau of Ethiopia where, among other places, the plant is indigenous Later, probably in the thirteenth or fourteenth century, the coffee shrub was introduced into Arabia. and from there the use of coffee spread over the entire Mohammedan world. Among the Arabs the story is told that one of the priests, having discovered that the monastery goats were restless at night after eating the berries of a certain shrub, tried feeding these berries to his monks to keep them awake during prayers. He first tried feeding them the berries and seeds, then he tried boiling the whole fruit, but as neither of these methods was successful he tried roasting and grinding the seeds and making an infusion from them. This made a palatable and stimulating

beverage, and thus, according to legend, was introduced to the world the art of coffee making.

Coffee culture gradually spread to India, the East Indies, and to the Western Hemisphere Until the latter part of the nineteenth century the East Indies were of such importance that "Java" still persists as a by-name for coffee. After about 1880, however, fungus diseases destroyed most of the plantations, and the cultivation of *Coffea arabica* became unprofitable in the East The chief centers of production shifted to South and Central America and the West Indies, where they still remain

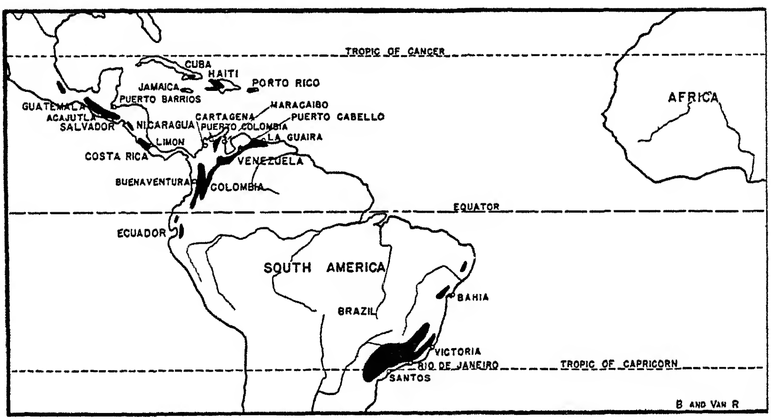


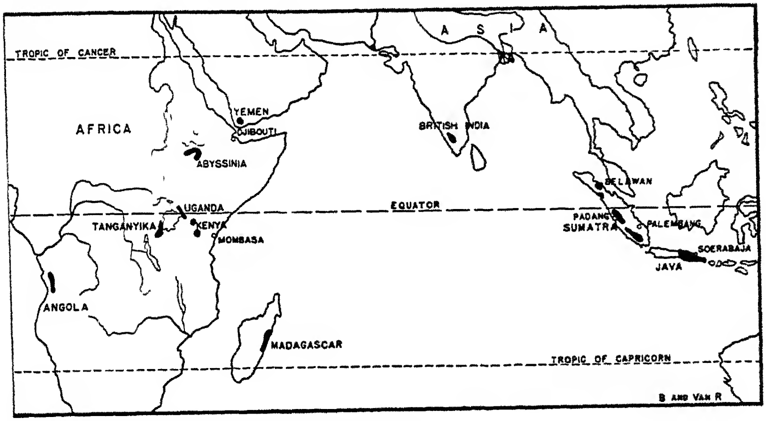
Fig. 199.—Principal coffee producing regions

Natural conditions favorable for coffee culture.—Although there are many species of trees and shrubs which belong to the genus *Coffea,* only a few have been found suitable for coffee production. These are *Coffea arabica,* and *Coffea robusta,* both tall shrubs, and *Coffea liberica,* a small tree The first named is probably a native of Abyssinia and grows best in tropical highland areas, whereas the latter two are natives of the Congo basin and of Liberia and do well at somewhat lower altitudes Most of the commercial coffee crop of the world is a product of different varieties of *Coffea arabica,* prized because of the superior flavor of the beverage made from the beans of this species *Coffea robusta,* because of its resistance to fungus di-

seases, is grown extensively in Netherland India, while some *liberica* is still grown in Africa

The coffee tree is a tropical plant and requires a warm moist climate. The arabica is a typical highland crop and does best at altitudes of 2,500 to 6,000 feet, where the average temperatures of the warmest and coldest months range between 82°F. and 55°F. respectively, where the days may be quite warm, 90°F. or more, but where the temperatures at night may occasionally drop as low as 40°F

Coffee requires much moisture and hence an annual rainfall of 50 to 100 inches is generally deemed favorable. A warm,



of the world and principal ports of export.

relatively dry period during the picking season is desirable Irrigation must ordinarily be practiced where the annual rainfall is less than about 40 inches, because coffee is not tolerant of drought In general, hills rather than valleys are preferred as sites for plantations, because coffee grows best where both air and water drainage are adequate.

Rich soils are needed for coffee production. Inasmuch as heavy rainfall, which causes loss of soil fertility by leaching, is nevertheless a plant requirement, it is quite apparent that not all the high rainy tropics are likely to be good coffee lands The soils most favored for plantations are those of volcanic origin, where weathering is actively breaking down lavas and liberating

the essential plant foods. The finest coffee lands of Java, Sumatra, Brazil, Colombia, Central America, and Mexico all have rich and deep loamy soils derived from young volcanics It is claimed that on some of the best coffee lands in Central America and Brazil the loose mantle rock reaches depths of 100 to 200 feet. Ample opportunity there for root penetration!

Present distribution of the coffee industry.—From its original indigenous home in the highlands of Abyssinia, Coffea arabica has spread so that it now can be found in the entire tropical belt of the globe, and commercial coffee production has become an important industry, dependent upon the successful coördination of various natural and social factors At present the commercial crop of the New World comes largely from the well watered highlands of southeastern Brazil, Colombia, Venezuela, Central America, southern Mexico, and the higher slope lands of Haiti, Puerto Rico, and Jamaica In the Old World the principal regions of production are Netherland India, British India, Turkey, and Ethiopia.

South America contributes nearly 75 per cent of the coffee exports of the world Among the exporting countries, Brazil easily ranks first, although its fraction of the total declined from about 75% in 1906 to 62% in 1930 Colombia in recent years has furnished about 10 per cent of the total coffee exports, while Netherland India has held third place with about 6 per cent.

Brazil is the undisputed lord of the coffee world It is estimated that between 65 and 70 per cent of all the bearing coffee trees in the world are in Brazil. In parts of the country the light green of the plantations is the most conspicuous feature of the cultural landscape, and men even think in terms of coffee. The principal producing region is the southeastern plateau, a highland area which slopes westward from the Coast Ranges toward the Parana River in the interior On this plateau, at altitudes of 1,000 to 2,500 feet, are thousands of square miles of rich red soil capable of producing several times as much coffee as the world needs The rainfall in the Sao Paulo district, about 60 to 75 inches per year, is most favorably distributed, the major part occurring during the growing season of the coffee

berry and little during the cool period of the year. May to September, which is the ripening and picking season. This part of Brazil has well defined seasons, and hence the entire coffee crop reaches maturity and is ready to pick at about the same time, usually beginning in late June. Inasmuch as coffee picking can be done only by hand, this one-period harvest involves a larger labor need than where the ripening period is more prolonged, as is the case in some of the regions of northern South America.

Courtesy, Bureau of Coffee Information

Fig. 200.—Large coffee plantation, known as a "fazenda," in Brazil. Note extensiveness of plantation on upland and absence of coffee trees in valley in left distance.

Since coffee is the principal support of a large part of the population in Brazil, it is obvious that failure of the crop or a prolonged period of overproduction will result in economic distress.

Because of the large profits which were formerly realized by the Brazilian growers, the acreage in coffee plantations was enormously increased Lack of careful study of potential market demands and lack of planning in accordance with demands led to overexpansion, overproduction and disastrously low

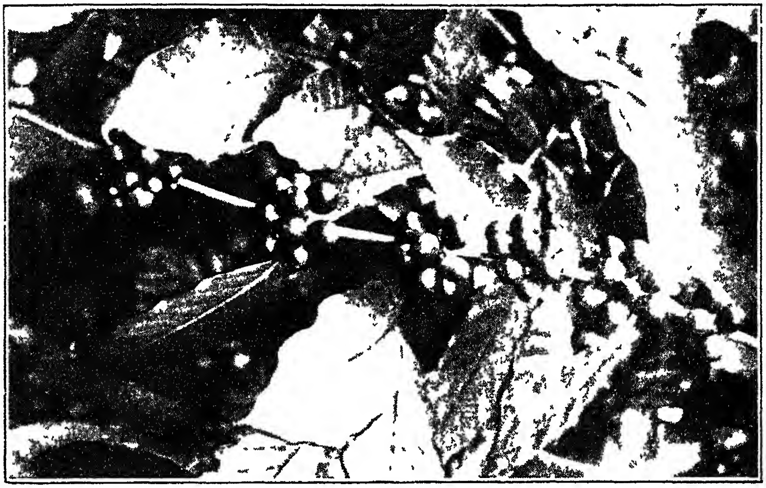
prices. The Brazilian government therefore resorted to a system of price control, buying up large stocks of coffee with the idea of holding them until prices improved and then releasing them gradually In its earlier stages this so-called "valorization" scheme met with considerable success. Soon, however, the trade began to seek supplies in other countries where sustained prices had made it profitable to increase coffee production. The accumulated Brazilian surpluses could not be absorbed by the existing markets, little was done to develop new markets, and as a result it was considered necessary to destroy large stores of coffee without any return, a practice that has been followed until very recently. As a permanent policy, the attempts of any single nation to increase prosperity through destruction not only is harmful to the welfare of the world as a whole, but in the majority of cases, seems doomed to failure Planning through international coöperation on a sound, economic basis is necessary even where one country holds such undisputed leadership in production as Brazil holds in coffee

In addition to Brazil, coffee is produced in every country of the Western Hemisphere from Argentina to southern Mexico. Production has been increasing on the highlands which extend from Colombia through Central America into southern Mexico, because of the favorable soil and climatic conditions and the fine flavored coffee grown there. Furthermore, increased plantings have been fostered by the low prices of suitable land and the readily accessible American markets. It seems highly probable that some further expansion will occur in these regions

Commercial production is also of importance in Haiti, Cuba, Puerto Rico, and Jamaica Haiti has a well developed market in France. Cuba can expand her production, although for the past 20 years sugar has been a more promising crop and hence has received principal attention Puerto Rico is favored by a cheap and abundant labor supply and by her direct trade connections with the United States. The Blue Mountain coffee of Jamaica has the reputation of being equal to the world's best and so commands a premium in the European markets

In the Eastern Hemisphere, Netherland India holds a com-

manding lead in export trade The coffee is grown mostly in the mountains of eastern Java and western Sumatra, preferably at altitudes between 1,000 and 3,000 feet. The principal species planted is *Coffea robusta,* because of its resistance to fungus diseases, although in some districts *Coffea arabica* is still grown The Arabian coffee is produced under irrigation in the coastal kingdom of Yemen, where the processes of cultivation picking, and curing are under the supervision of British experts That the trade considers the Arabian coffee to be of superior quality



Courtesy, Bureau of Coffee Information and National Federation of Coffee Growers of Colombia

Fig. 201.—Coffee in the "cherry," about ready for picking.

is evinced by the generally high prices paid in European markets. It seems somewhat anomalous that the British, noted as tea drinkers, should be in such positions of prominence as producers of fine coffee in both Arabia and Jamaica

International trade in coffee.—For decades the two great coffee trade currents of the world ran from the West Indies to France, England, the Netherlands, and Germany, and from Netherland India to the Netherlands. During the nineteenth century, however, they were gradually displaced by two new currents—namely, one from Brazil to the United States and one from Brazil to Europe By 1855 Brazil was contributing

nearly 50 per cent of the coffee imports of the northern countries. This percentage increased so that at the opening of the twentieth century she furnished slightly more than 75 per cent Since 1910 Brazil has lost ground, so that in recent years she has furnished only about 60 per cent of the world's coffee imports. Nevertheless, the world's chief coffee stream is still from Santos and Rio de Janeiro to New York, with lesser ones from Brazil and from the East Indies to western Europe.

Nearly half of the coffee exports of the world go to the United States. In this country consumption has risen from three pounds per capita in 1830 to nearly 13 pounds in 1930 Since most of the American imports come from Brazil, the commercial and economic ties between the two countries are close. The increase in imports from more northern tropical countries has slightly reduced the percentage received from Brazil, the change being accounted for by the preference in the United States for a larger admixture of mild coffees in the blends which are sold under widely advertised trade names.

Coffee is appreciated as a beverage by people in all walks of life. It cheers alike the weary toiler and the jaded society belle Its introduction had to overcome religious, political, and physiological prejudices, and in many countries even now economic barriers in the form of taxes and duties obstruct its path It has, however, won such universal favor that the permanence of its position as one of the great commercial products of the world seems assured.

SPICES

The products which, in the minds of many inhabitants of middle and high latitudes, are most intimately associated with the word tropics are the spices This association of ideas is, however, chiefly a survival of times past The spices now play only a minor role among the products of the tropics which enter world trade.

In many tropical countries the food of the natives is highly seasoned. Whether this is a physiological response to climatic conditions or whether it is the result of the tastelessness of the native diet, particularly of a rice diet, remains an open question,

but spices have been known and used for untold centuries in the warmer regions of the earth

Even in pre-Roman times small quantities of these products reached the West, and, according to some, became immensely popular among the rich because of the often doubtful quality of the meat in a region with hot Mediterranean summers and without refrigerating equipment Thus, the basis was laid for the famous spice trade, which was partly responsible for the wealth of Venice and Genoa, for the discovery voyages of Portuguese and Spanish, and for the foundation of Colonial empires, such as those of Great Britain and of the Netherlands. Spices were small of bulk, high of value, and they kept well. They were therefore eminently suitable to sustain an early trade which could deal only in luxuries because of the time consumed, the hazards concerned, and the small size of a camel's load or even of a ship's cargo.

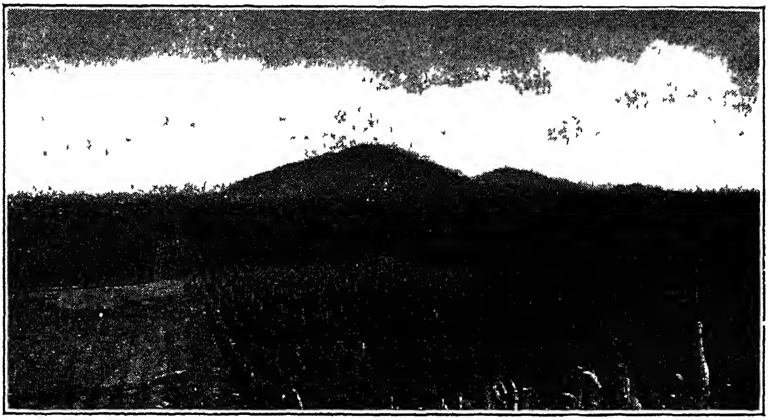
At present, most of those spices, which once brought their weight in gold, are now common kitchen ingredients; and although they have lost their dominant place in the trade with the tropics, the total volume of many of these products entering world trade, is vastly greater than it was in the sixteenth and seventeenth centuries.

Distribution.—Among the spices, *pepper* (Piper nigrum) stands first It is a vine which, like ivy, fastens itself to a support, a pole, or a living tree with not too dense a crown The pepper plant can be grown only where both temperature and humidity are constantly high The fruit is a red berry which grows in bunches of 20 to 50; each berry contains one seed, the real peppercorn. If picked green, and dried, the berries become dark and wrinkly, the pericarp adhering to the seed This is the so-called black pepper. White pepper is produced by removing the pulp from the seeds.

Netherland India is the principal producer of pepper, accounting for more than 70 per cent of the world production. The pepper gardens are mostly in the hands of the natives, but the trade in pepper which centers in Batavia is dominated by Chinese.

British India produces considerable amounts of pepper on the warm and humid Malabar Coast. Other, minor, centers of production are found in the southwest coast of French Indo-China, in Sarawak, Ceylon, and British Malaya The latter region shows unexpectedly high exports. A large percentage of these exports, however, originate in nearby Netherland India, and are sold through the important Malayan trade centers of Singapore and Penang.

Cloves are the dried flower buds of a tropical tree (Eugenia caryophyllata), found originally in wild state in the Molucca



Courtesy, Departement van Landbouw, Netherland India

Fig. 202.—Pepper gardens in southern Sumatra. Note their extensiveness and the supports provided for each plant.

or Spice islands During the seventeenth and eighteenth centuries the Dutch had a virtual monopoly on the trade in cloves This monopoly was broken by the French, who succeeded in transplanting some clove trees to their island possessions in the Indian Ocean (Réunion). At present most of the cloves entering world trade are produced on the little islands of Zanzibar and Pemba, on the east coast of Africa, which enjoy a warm and very humid climate.

Cinnamon is the inner bark of a small tree (Cinnamonum zeylanicum) which is cultivated principally in the damp lower hills and coastal plains of southwestern Ceylon, while Java is a minor center of production Since the aim of the cinnamon in-

dustry is to obtain as much bark as possible, the plant is pruned to bush form During the rainy season branches of a certain length are cut, and the bark is carefully peeled off and dried Closely related to the Ceylon cinnamon is *cassia*, a product of wild or cultivated varieties of cinnamon trees which grow in British India, Netherland India, French Indo-China, and southern China This is inferior to the Ceylon product, but it is often used as a substitute for it.

The *nutmeg* tree (Myristica fragrans) also requires a truly tropical climate and is grown mainly in Netherland India. Once one of the highly valued spices, the nutmeg has lost much of its former popularity

The *vanilla* plant is an orchid which entwines itself around trees. Because it needs dry weather during the flowering period, it is best adapted to the marginal areas of the tropics where pronounced dry seasons prevail The principal producers of vanilla are Mexico, Réunion, the humid north and east coasts of Madagascar, and neighboring islands In recent years the industry has suffered greatly from the competition of synthetic vanilla, which has a much stronger flavoring power than natural vanilla

Among other essentially tropical spices should be mentioned *ginger* (Zingiber officinale)—the rhizome of a plant which is cultivated in the marginal districts of the tropics and even in the subtropics (southern China, India, Jamaica)—and the *Cayenne pepper* or *chili* of Central America and the West Indies.

MEDICINAL PRODUCTS

The tropical regions are important sources of a number of medicinal products, among which *quinine* is undoubtedly the most valuable. Quinine and mosquito netting are in many parts of the world practically the only means to combat that great scourge of humanity, the malaria fever. Quinine is extracted from the bark of the cinchona tree, which grows wild in the forests of the eastern slope of the Andes Mountains. It is a tree of the tropical highlands occurring mostly at altitudes be-

tween 3,000 and 8,000 feet. As a result of the inaccessibility of the Andean forests and the destructive methods formerly practiced by the native searchers for bark, there has developed a plantation industry whose output has superseded entirely that of the wild tree This industry centers in the East Indies, especially on some of the mountain slopes of western Java, and now supplies more than nine-tenths of the world's quinine.

Outside of Netherland India, cinchona plantations are found in British India on the slopes of the Himalayas, and in Madras, while small quantities of South American cinchona still reach the principal markets.

The leaves of the *coca bush* (Erythroxylon coca), which is grown on the eastern slopes of the Andes, at elevations of 2,000 to 5,000 feet, are chewed by the Indians, during work as well as on the march The stimulating effect of the leaves is due to their content of *cocaine,* a dangerous, habit forming drug when wrongly used, but which is indispensable to the medical profession.

Similar, but much less dangerous, stimulating alkaloids are contained in the *kola nut.* This is the seed of the kola tree (Sterculia acuminata), which is grown extensively by the natives of western Africa, at the edge of the tropical forest The kola nut is the chewing gum of Africa, and in polite African society it plays the same role that a cigar or a box of candy plays in our Western culture sphere.

TROPICAL WOODS

Perhaps the greatest resources of the warm, humid regions are the forests, especially the immense tropical rain forests which cover with a heavy mantle of everlasting green so much of northern South America, of Central Africa, and of the Australasian islands These forests, in contrast to most of those in higher latitudes, consist nearly entirely of hardwoods. Softwoods—i.e , coniferous trees—occur in various places, particularly on plateaus and higher mountain slopes, but their total acreage is small in comparison with the area occupied by the hardwoods.

The tropical rain forests have no prolonged annual period of rest. Conditions are so favorable for assimilative processes throughout the year that many species do not show the pronounced growth rings which are so typical of the trees of the middle latitudes. Tropical woods often have a fine, even texture, and they may occasionally be of a remarkable hardness and weight. Various types of so-called "iron woods," with a specific gravity greater than that of water, are common throughout the rainy tropics.

Commercial production.—Notwithstanding the excellent quality of some of the wood, only a very small percentage of the tropical timber resources is commercially exploited at the present time. In a few regions agriculture, in its search for new virgin crop lands, is making extensive inroads into the rain forest. Such is true, for example, in the cacao districts of the Gold Coast, where the British colonial government has considered it necessary to declare part of the tropical forest a permanent reserve. Similar reserves have been set aside in Netherland India and are being gradually expanded for the protection of the watersheds. Nevertheless, the tropical rain forest is as yet, a reserve of timber relatively untouched.

There are several reasons why the tropical hardwood forests have not gone the way of most of the hardwood and a considerable part of the softwood forests in Europe and North America. In the rain forest, although they are by no means absent, pure stands of trees rarely occur. In an acre of tropical forest one will find, as a rule, not less than a dozen different species, and many more varieties, of trees. Such greatly mixed stands seriously handicap any attempt at commercial exploitation. Furthermore, a certain percentage of the timber, because of too fast growth, may be of rather poor quality, with coarse or uneven texture To this must be added numerous difficulties of a physical nature. unhealthful climate, dense undergrowth, and soft, swampy ground Transportation is laborious and expensive, and shipping points are usually far from the centers of consumption.

Under such conditions and as long as great quantities of tim-

ber can be cut at relatively low cost in the temperate regions, the ordinary hardwood of the rain forest cannot compete in the world markets. Only those woods which excel because of hardness, color, grain, or fragrance, especially the so-called precious or cabinet woods, can stand the high cost of production and marketing. Of these a considerable number, under greatly varying names, reach the western markets. One of the principal handicaps of the trade in tropical woods is that, from a botanical point of view, the forests of the warm humid regions are still very imperfectly known, and that similar popular or trade names often cover widely divergent species the wood of which may appear identical at first sight but may have greatly different properties.

Some of the precious and semi-precious woods have been made the objects of world-wide search, and their names have become familiar in most of the Western World Mahogany, cedar, and teak wood rank foremost in this respect

Distribution.—True *mahogany* (Swietenia) is much sought after for fine cabinet work It is hard, has a beautiful grain and a rich color which improves with time, and can be applied as a veneer. It occurs only in southern Mexico, Central America, the West Indies, and northwestern South America At present Mexico is the largest shipper of mahogany, while Honduras and British Honduras have always been noted as producers of exceptionally good types of this wood

There are several kinds of wood which resemble true mahogany and to which the name mahogany is often loosely applied. Among the most important of these is the closely related African mahogany (Khaya), which is found on the Guinea Coast. The Ivory Coast is the principal exporter of this type of wood The East Indies also produce some woods which resemble true mahogany.

A type of wood which always conjures up pictures of tropical lands is *ebony*. Ebony, slaves, and ivory once were the principal products of trade in tropical Africa, and ebony was sought after as early as the days of King Solomon. The wood is very

hard, usually coal black, and exceedingly fine grained. The trees which produce it are found in the forests of Africa and of southeastern Asia As is the case with mahogany, there exist various other woods which closely resemble ebony and often enter the trade under that name

Where accessible, the tropical *cedars* (Cedrela) have been exploited to the verge of extinction Cedar wood is of a reddish color and is soft and fragrant Especially because of the latter quality it is in great demand for the manufacture of cigar boxes. Cedar trees have a wide range, from southern Mexico to southern South America. The cedar trees of the Far East (Toona) are closely related to the true cedar, and their woods are practically identical Central America, Brazil, and Mexico furnish most of the tropical cedar now used.

Another wood which is in great demand for its strength and durability is *teak* The teak tree does best where there is a dry season of several months duration. It is found, therefore, most abundantly in the deciduous monsoon forests of southeastern Asia, especially of Burma and Siam, eastern Java, and the Philippines. Since teak occurs in pure stands, it can easily be exploited At present some of the principal stands of teak trees are under scientific silvicultural management.

Among the large number of other tropical woods may be mentioned *sandal wood, satin wood* and *rose wood*

Other important economic products of the tropical forests are the resins and nuts, the harvest of which in many of the more sparsely settled districts constitutes the principal source of cash income for the native population. Among the various kinds of resins the best known are the *hard copals* and the *soft copals* or *damars,* furnished by a number of different species throughout the tropics The hard copals are used extensively in the manufacture of varnishes and are exported mainly from East Africa, Madagascar, the Guinea Coast, the Congo region and southeastern Asia.

Southeastern Asia is the principal source of *rattan,* used in the manufacture of chairs and cane seats for chairs. Among

the nuts of the warm rainy forests the best known are *tagua nuts, corozo nuts,* and *Brazil nuts* The first two furnish the so-called vegetable ivory, used in the manufacture of buttons.

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CHAPTER XVIII

The Regions of Warm and Dry Climates

THE climate may be classified as *dry* wherever the rainfall is sufficient to support tree growth on the uplands. Although other factors may contribute to the absence of trees, aridity is the fundamental cause for the existence of most of the treeless areas in the warm climates. As pointed out in the preceding chapters, the equatorial belt is rainy. On each side of this rainy zone, in latitudes 20 to 30 degrees north and south of the equator lie belts where little rain falls. These dry belts, crossed by the Tropics of Cancer and Capricorn, are often referred to as the tropical desert areas. The middle portions are extremely dry, in places almost rainless, and are bordered by semi-arid belts which mark the transition to the humid climates farther north and south. This broad zonation of rainfall over the warmer part of the earth is one of the most fundamental facts in the economic geography of the world. It is the principal factor to be considered in accounting for the differences in agricultural practices and the diversity of crops produced within the lower latitudes.

From a causal point of view, the heavy rains in the equatorial regions and the semi-arid to arid conditions near the tropics are closely associated with differences in atmospheric pressure. The equatorial belt is characterized by comparatively low pressure, the average annual being below 30 inches. Thus, the low pressure belt along the Equator, where the air is in ascending motion, is characterized by heavy rainfall, whereas in the high pressure belt along the tropics, where the air is generally descending, but little rain falls

Where the rainfall suffices to support only short grass turf, or scanty bush or shrub vegetation, the climate is classified as

semi-arid. Where the rainfall is so slight that the sparse vegetation is dormant most of the time, where the landscape is characteristically brown rather than seasonally green, there is the desert, a product of the arid type of climate. Although the amount of annual rainfall is not always a reliable criterion, the deserts of the warm zone generally have less than 10 inches of rain per year, while semi-arid lands receive an average annual rainfall of 10 to 20 inches. In short, deserts are land wastes with little vegetation The rainfall in the desert is slight and irregular, the landscape is brown or gray, except when the infrequent rains give rise to brief periods of green. In semi-arid lands, where the rainfall is somewhat heavier, the short grass or scattered shrub vegetation presents a green landscape regularly for a few months each year.

Inasmuch as low rainfall is the critical factor in arid and semi-arid lands in both the low and the middle latitudes, it seems advisable to use a nomenclature that clearly recognizes this fact. The term *desert* has won universal recognition as a name for dry lands, and is so used in all latitudes. It seems justifiable to use the term *steppe* in similar manner for semi-arid lands, whether they occur in middle or in low latitudes.

THE TROPICAL STEPPES

The largest areas of warm, semi-arid lands occur in Africa, where the northern Sudan (the "Sahel") and the Kalahari steppes are prominent examples of this type The Sudan steppe lands extend entirely across the continent, from Senegambia to Somaliland. Although varying considerably in their aspects from place to place, they possess the common characteristic of a native flora of scattered thorny bush or short grass, while along the permanent and intermittent water courses some trees occur Southward the Sudan steppe merges imperceptibly into the tropical savanna lands, northward it merges into the desert The Kalahari ranges from a pure grass steppe in the southern section to mixed acacia, bush, and grass in the central part Westward it merges into true desert, the Namib, while east-

ward it merges into the deciduous forest lands of Angola and northern Rhodesia.

In Australia the semi-arid belt borders the arid interior on the north and east, being the transition zone between the rainier coastal strips and the almost rainless interior In South America the most extensive area of warm, semi-arid land lies in eastern Brazil, where much of the basin of the Sao Francisco River suffers from insufficient rainfall. Smaller areas occur in northern Argentina and southern Bolivia—the Gran Chaco—and in southwestern Ecuador.

In the Northern Hemisphere the most typical areas of warm, semi-arid steppes include much of Lower California and part of the Plateau of Mexico. In the dry areas of southern Europe and southwestern Asia, as well as of the higher slopelands of northern Africa, freezing temperatures are so common during the winter months that the climates are more characteristic of the middle latitudes than of the tropics, and therefore these areas are not included in the tropical steppes

Since the larger areas of warm, semi-arid steppes occur in Africa and Australia, the discussion which follows is based on conditions there rather than in North and South America.

General characteristics.—The most prominent features of the warm, semi-arid type of climate are the low annual rainfall, usually less than 20 inches, and its distinctly seasonal distribution The dry season lasts from six to nine months, with some months virtually rainless. The rainy season is generally associated with the high-sun period of the year, while the drought is most intense during the low-sun period. In seasonal distribution of rainfall, the tropical savannas are similar; both have summer rains and winter drought The difference between the two is one of degree rather than one of kind.

Temperatures, on the whole, show a greater seasonal rhythm than in any of the more humid climates thus far discussed. This is due chiefly to the greater distances from the equator at which the dry steppe lands occur, although the greater dryness of the air is also a contributing cause. The hottest season of the year usually occurs during the sun-high season, just before the rains

begin. There is but little cloudiness to reduce the intensity of the sunlight, and high temperatures during the daytime are the logical result At night, in the absence of clouds to retard the escape of heat, radiation is rapid and relatively low temperatures usually ensue

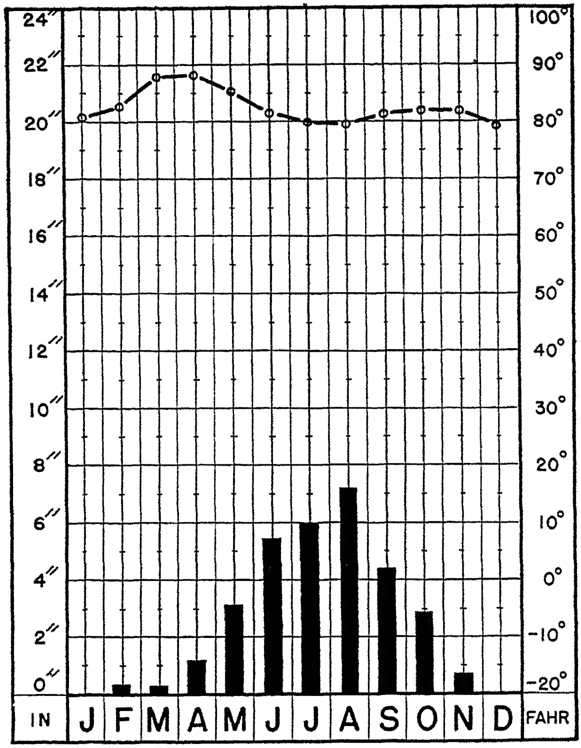


Fig 203.—Tropical steppe. Average temperature and precipitation, Hillet Doleib, near Malakal, Anglo-Egyptian Sudan. Altitude 1,283 feet, total precipitation 31 inches.

During the high-sun periods the warm, semi-arid climates are characterized by variable winds and light rains, mostly of the convectional type. The rains are rarely of long duration, although they may be quite heavy while they last. In the northern Sudan, northeasterly winds prevail during the dry season, blowing from the high pressure area of interior northern Africa toward the "low" which lies along the Guinea coast.

These dry winds give rise to a hazy, dusty atmospheric condition, but, because they promote evaporation, they feel cool and bring a sense of relief from the oppressive moist heat of the rainier period These northeasterlies are technically known as the *harmattan,* but more popularly are referred to as "the

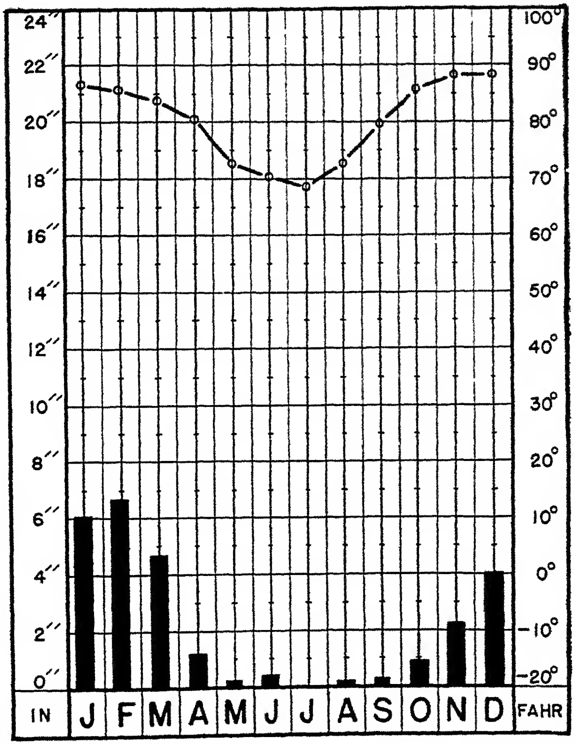


Fig 204 —Tropical steppe. Average temperature and precipitation, Daly Waters, Northern Territory, Australia. Altitude 633 feet, total precipitation 26 inches.

doctor" because of their bracing or energizing influence upon human activity. This influence, with equally favorable results, extends southward into the more humid areas.

The shifting of the winds from the calms and variables of the rainy season to the steady winds of tradewind type during the dry season is common for all the warm semi-arid regions. These regions are in general characterized by fairly well defined

RAINFALL AND TEMPERATURE DATA FOR NORTHERN SUDAN, AFRICA

Wagaduga, located south of Timbuktu, southern part of Sudan (Altitude 2,493 feet, Temperature in Degrees Fahrenheit, Rainfall in Inches)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
74 7	75 6	85 3	88 5	86 7	81 1	78 6	77 7	79 3	81 1	80 6	75 9	80 4
0	0.	0 1	1 8	2 5	4 5	6 2	10 6	5 0	1 3	0	0	32 0

El Obeid, located near Khartum, northern part of Sudan (Altitude, 1,860 feet, Temperature in Degrees Fahrenheit, Rainfall in Inches)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
70 0	74 8	82 2	88 5	89 8	88 2	82 5	82 0	84 2	85.4	78 7	72 0	81.5
0	0	0 2	0 1	0 4	1 2	4 1	4 6	3 9	0 8	0	0	15 3

wind shifts and accompanying moderate temperature changes Nevertheless, although the weather conditions are sufficiently varied to prevent the enervating monotony of the humid tropical type of climate, they can hardly be called pleasant and agreeable. High daytime temperatures, brilliant sunshine rarely cloud-obscured, hazy atmosphere laden with dust, dry parching winds, and little rain constitute a fair resume of the prevailing weather of the semi-arid tropical lands.

Native flora and fauna.—The landscape of the tropical steppes may be described as park-like The ground-zone of vegetation is low, consisting of grasses and low shrubs, either or both, with bare ground showing conspicuously in places The grasses are mostly of the bunchy types, rather coarse-stemmed, although in some areas fine short species thrive. The grasses provide forage for great numbers of grazing wild animals, and therefore give rise to areas popular for hunting so-called big game The ground-zone of vegetation is surmounted in many places by scattered bush or clumps of trees. The shrubs are characteristically thorny and the term "cat's claw," often used in describing them, is truly expressive. In general the leaves are small and leathery, so constructed as to conserve moisture and at the same time carry on the processes of transpiration and tissue building The root systems are shallow but extensive, thus being adapted for rapid absorption of such soil mois-

ture as becomes available following the showery rains. The taller forms of vegetation consist of isolated trees or small clumps of trees scattered here and there. On the uplands the trees are far apart, and the landscape presents broad views when observed from low hills or other eminences. Although the water courses are dry most of the time, the tree growth and thorny bush along them is quite plentiful because of the large supply of ground water. These strips of forest and bush may

Photo by H L Shantz.

Fig. 205.—Tropical short grass and bush steppe Kenya Colony, Africa.

be jungle-like in their density. The bark of the trees is usually thick, the leaves are narrow, and spines and thorns are numerous. The wood is generally hard, with twisted or gnarly structure, which makes it difficult to split or saw the logs into boards.

In most places the warm, semi-arid steppes have some sort of timber well suited for such simple construction purposes as are involved in building huts for people and corrals for livestock. Acacias and various tree cacti are common and useful for such purposes. The fuel needs are not great and the supply of tree and bush is usually ample. Grazing is the most

economic use that can be made of the land, the type of grazing being dependent upon the quality of feed available. Edible shrubs are the chief forms of vegetation, and since they are not abundant, only goats and camels prove successful. On the other hand, where grasses abound together with the more palatable species of shrub and bush, sheep are favored. The old adage, "goats on the lean lands, sheep on the fat lands," is quite literally fulfilled in man's use of dry steppe lands for grazing purposes.

Soils.—Since in regions of warm, semi-arid climate the rainfall is insufficient to produce heavy leaching, the soils are generally rich in lime and other minerals, and therefore belong to the pedocalic group. The color ranges from chestnut brown to gray as the desert conditions are approached In some areas, especially where grasses are quite abundant, soils so dark as to be classified as blackerths have been found. Where leaching is slight, there is a tendency for sodium salts to become concentrated in the profiles of semi-arid soils, this tendency being more pronounced as aridity is approached. Where, owing to topography, the groundwater level is near the surface, saline or alkaline soils may occur.

Where rainfall is so low that near-desert conditions prevail, the soils are generally immature because of incomplete chemical weathering and unfavorable conditions for organic activity. The colors are usually grayish, often light Such soils are rich in mineral constituents—in many cases excessively so, with resultant alkali conditions—while they are deficient in humus.

On the whole, however, the soils of the steppes average fairly high in potential productivity, their mineral content is ample. their structure is stable, and they are easily tilled. The problem of agricultural production is one of water supply rather than of soil fertility.

Agricultural practices and possibilities.—The warm semi-arid lands are natural grazing grounds. The native animal life is either fleet footed or fleet winged and thus is able to move rapidly and over long distances to obtain water The exceptions—that is, those species which are not swift of foot or wing

—are well protected by thick skin or scales, so that existence with little water is possible. The warm steppe is the land of the antelope family, which is able to subsist on the moisture found in grass and in leathery leafed shrubs when other water supplies fail In southern Africa part of it is known as the *veld,* which once harbored multitudes of gembok, wildebeest, and hartebeest. Insect life is abundant. The warm semi-arid lands of Africa, Australia, and of northern Argentina are noted as being the breeding places for hordes of locusts which swarm into more humid sections during dry years, causing heavy damage to crops and native vegetation.

Wherever man attempts to develop economic pursuits in the warm, semi-arid lands, either he must adapt himself to the climate and native plant and animal life, or he must overcome whatever handicaps are encountered In the areas where moisture is sufficient, or where it is provided through irrigation, some crops can be grown, as, for example, sorghums, millets, and barley. Thus, grain for food and for feed can be provided. In general, however, there is but little grain farming in the warm, dry lands of the world; some form of herding is the dominant economic pursuit, and the people are mostly nomads Small scale cultivation can produce a valuable harvest only where conditions permit relatively large yields per acre, and these are not possible when rainfall is deficient. In some places people carry on quite well during periods of relatively heavy rains; then when a period of drought follows, with attendant sparseness of grass and failure of crops, migration becomes necessary. Whole clans with their herds and flocks go on the move—the centuries-old trek for water and grass.

Extensive development of the semi-arid tropical lands must await such time as the increased population of the world will have utilized the humid savannas and when man will have to be satisfied with the less desirable areas. Then choice will have to be made between the dense jungle and the rain forest of the equatorial belt on the one hand and the semi-arid steppes on the other. From the standpoint of middle latitude demands, the chances favor the warm wet lands because their products

cannot be duplicated in the cooler lands, whereas the animal products of the warm semi-arid countries do not differ greatly from those of cooler climes For example, bananas, coconuts, and cacao, products of the warm humid lands, have no competitors in the northern markets, on the other hand, products of the warm, dry lands, such as tropical goats, sheep, and cattle, have no such monopoly, but must meet the direct competition of their kind produced in cooler climates and generally under more favorable conditions as to environment and markets.

THE WARM DESERTS

It is estimated that 12 to 15 per cent of the land area of the earth is dry desert The climatic map shows clearly that the largest extent of dry deserts lies in the relatively low latitudes and that most of the great deserts lie in the vicinity of the two tropics From a climatological point of view we may say that their location is poleward from the tropical semi-arid lands, and that the deserts constitute a sort of dry divide between the rainy lands of the low latitudes and those of the middle latitudes (Fig. 300)

As stated at the outset of this chapter, the term *desert* is not limited to lands wholly devoid of vegetation It includes also areas where the vegetation is dormant most of the time and where the landscape is characteristically brown, although occasionally rains may turn it into brilliant green and cause it to become flower-besprinkled for short periods The true desert is of course a rock or sand waste, but as ordinarily used the term is somewhat more inclusive

Climatic characteristics.—Stated broadly, the tropical desert belts of the world are characterized by relatively high atmospheric pressure, the average barometric readings being well above 30 inches. Lower pressures prevail both poleward and equatorward, and therefore these belts are not only divides between rainy belts on either side, but are also high pressure divides between adjacent areas of lower pressures. The prevalent high pressure results in a general descending movement of the

air from higher to lower altitudes. As air masses descend they are warmed by compression (adiabatic heating) and also by mixing with the warmer air near the land surface and by contact with the warmer land itself Thus, since the moisture-holding capacity of the air is increased by its rising temperature, the tendency to precipitation is diminished and little or no rain falls This is in direct contrast to the atmospheric conditions dominant in the equatorial belt, where low pressures prevail and the ascending masses of air, chilled by expansion (adiabatic cooling), give rise to copious rainfall.

Irregular as to occurrence and torrential as to volume are the outstanding characteristics of the rainfall in the desert. At a given place, months, even years, may elapse during which no rain whatever falls. Occasionally, however, sufficient moisture may be in the air so that under the influence of rapidly ascending convectional currents, thunder clouds may develop and heavy showers of rain result Since life in the desert is adapted to aridity, great damage is sometimes done by such rains. A place which has had no rain for several years may receive three or four inches within a few hours. For a short time it may fall in torrents, producing a veritable "cloudburst" which quickly inundates the flat lands, changes dry stream beds into raging water courses, and destroys earth houses in which the natives dwell. The French soldiers stationed in the Sahara have strict orders *never* to camp in the *wadis* (the dry stream channels) because of the danger of sudden catastrophes of this kind. But the rainstorms are short lived. The clouds quickly disappear, brilliant sunshine returns, and soon the landscape again presents the shifting hues of the desert.

Temperatures and winds are subject to similar fluctuations The changes in temperature from day to night are greater, in most cases, than are the changes from season to season. The range of *average* daily temperature summer to winter—that is, from the warm season to the cool—is rarely more than 30 or 40 degrees Fahrenheit. On the other hand, daytime temperatures above 100°F. are not uncommon, while at night the temperature may occasionally drop nearly to the freezing point.

This violent daily range is a source of discomfort to man and beast—roast at midday, freeze at midnight.

The winds are erratic, frequently shifting in direction and velocity, and the humidity is always low. Owing to heating of the sands during the daytime, stinging winds, now from this direction, now from that, are almost the rule The sand-carry-

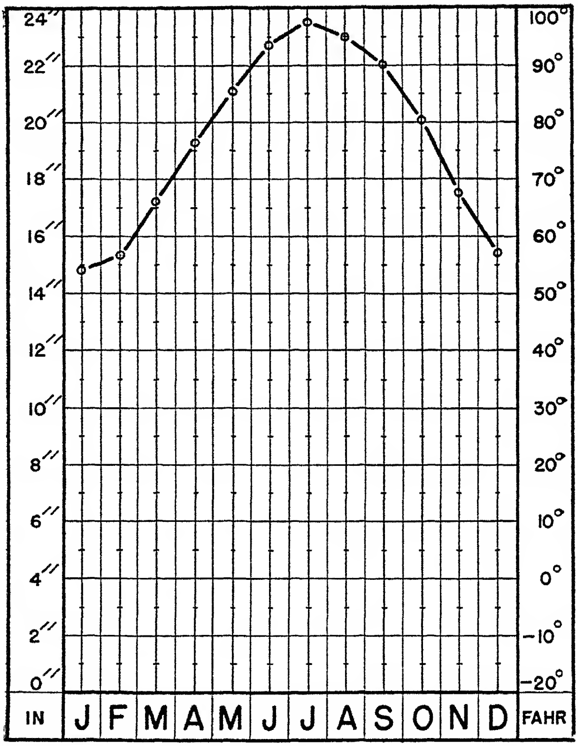
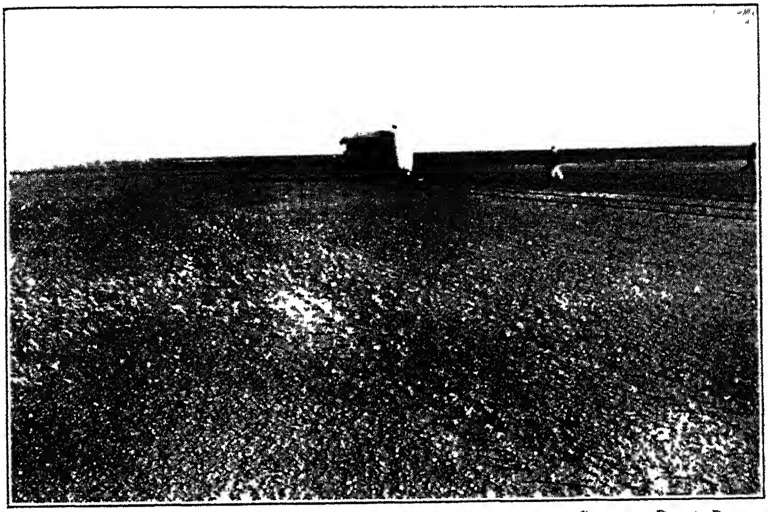


Fig. 206.—Tropical desert. Diagram of temperature and precipitation for In-Salah, Sahara. Altitude 1,080 feet, no precipitation recorded.

ing winds in the desert are perhaps the greatest source of discomfort experienced. The hardships of travelers who encounter severe sandstorms have often been told and so are quite well known, but that the desert is nearly always windy is not so generally understood The bare rock wastes or hot sands give rise to uneven pressure and unstable conditions in the lower strata of the air. Thus, currents develop and the rapid

movement of air near the surface from one place to another gives rise to the strong, variable winds usually experienced These winds, low in moisture, of high temperature, dust and sand laden, cause parched skins and cracked lips for those not hardened to them, and discomfort in varying degree to man and beast.

Where the desert reaches its full development as an expanse of bare rock (hammada) or of shifting sand, it has associated with it the lure of ever-changing landscape. Thus, the desert



Courtesy, Payot, Paris

Fig. 207.—"Reg," or pebble pavement desert, central Sahara. (From E. F. Gautier, *Le Sahara*)

has been the place where man could experience Nature's unbridled forces, and from it have come some of the most eloquent portrayals of landscape ever penned. "The Sahara, though frequently tawny in spots, runs through the whole gamut of colors. In the early morning it is a dirty bluish gray, of much the same tone as the refuse from a soda-ash manufactory; but as the sun rises it becomes a dazzling white, like drifted snow, so glaring that the eyes must be protected with tinted glasses. Under certain atmospheric conditions, however, I have seen the outcropping rocks of the *hammada* become as red as the

walls of the Grand Canyon. But the desert assumes its loveliest tints with the approach of nightfall, when it gradually changes from white to vivid orange, to blue, to amethyst, to deepest purple Then, when the stars come out, it changes to gray again, an indescribably soft and misty gray, like smoky chiffon over silver tissue"[1]

With minor changes as to detail, the description so vividly given for the Sahara would fit any of the other great deserts of the tropical high pressure belt—the Arabian, the Thar, the great desert of Australia, the Namib, or the Atacama The centers of these areas are rocky plateaus and sandy wastes, but from those centers outward there is a gradual change from bareness of vegetation, through scattered bush and shrub, to the more richly clothed grass and tree steppes The heart of the desert, the true wasteland, is without human occupance; it is a place to be traversed if need be, but not to be lived in.

Utilization of desert lands.—Human occupancy of the land begins where grass meets sand or rock waste—the edge of the true desert This edge is a transition zone of varying width where some verdure is found but where the rainfall is so scarce that the classification of desert still holds true The transition zone advances from the desert in dry years and recedes when years are wetter than normal. There, at the edge of the desert, man pushes ahead with the rains and retreats with their absence This is the zone of mobility. When moisture comes, plants flourish, and man prospers because flocks of goats or sheep can make use of the pasturage When rains fail, grass fails, and man and his flocks must move on to other pastures. The edge of the desert is the realm of the nomad

The native flora.—The native plants at the desert's edge are highly specialized to conserve and utilize moisture when it is available. This specialization is observable in the root systems, in the leaf and stem structure, and in the distribution of the plants The root system is shallow and intricate, literally filling the upper few inches of the soil zone with a maze of

[1] Powell, E Alexander *In Barbary,* D Appleton-Century Co, New York, 1926

roots and rootlets When the occasional dashing rains come and wet the grounds to shallow depths, this intricate network of roots springs into action and literally drinks up the water before it has time to escape by evaporation into the atmosphere. Plants, such as the cacti, have developed thick roots and fleshy stems and leaves by means of which they conserve the needed moisture A large percentage of the plants are equipped with leaves and stems which have glossy skins sometimes underlain with cork-like zones; such structures retard evaporation and cause a little water to last a long time in sup-

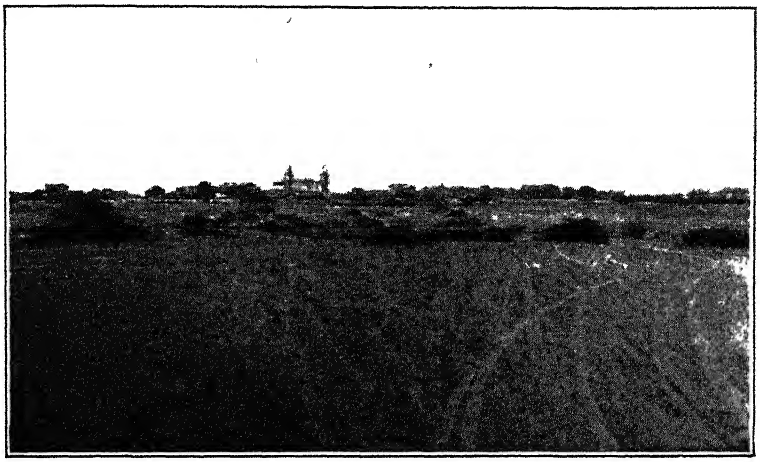


Photo by N. A B

Fig. 208.—Scattered shrubs at desert's edge, Santa Elena Peninsula, Ecuador.

porting the circulation of the plant. Furthermore, plants grow far apart, thus providing for each a relatively large area for occupancy by roots and for catchment of rain water. These types of vegetation furnish sustenance for pasturage and are suggestive of what man must do if he would succeed with planted crops.

Soils.—Desert soils rarely develop distinct profiles such as are characteristic of soils in humid areas. In deserts the actual weathering is mainly physical; because of the lack of water, chemical weathering is slow notwithstanding the high temperatures which prevail in the tropical latitudes. As a result of

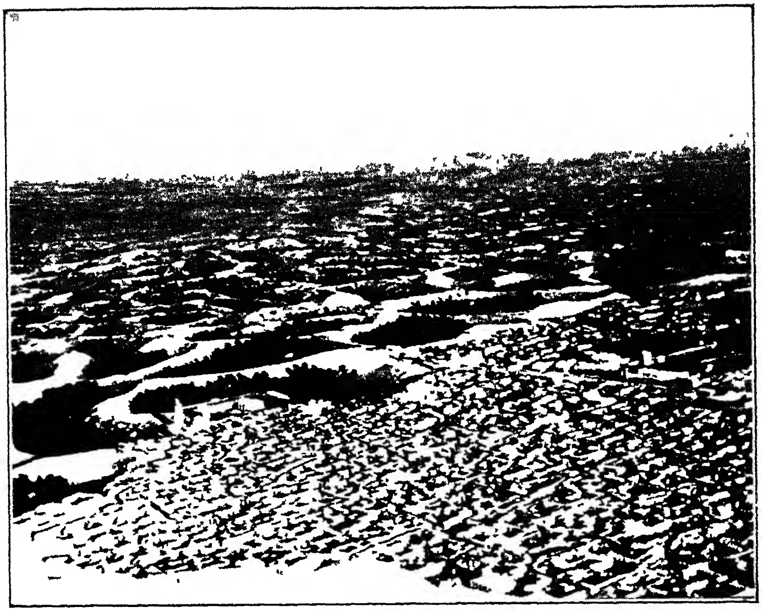
the disintegrating processes, sands, rather than clays and silts, are dominant Finer materials, however, are often found to be present in desert soils, having been carried in by winds from more humid areas. Since the land surface lacks the protection of a well established vegetative cover, wind erosion is marked; desert pavements, consisting of rock platforms or rock fragments from which the finer materials have been swept away by wind action, are well-known features of dry deserts. In other cases, areas of shifting sand make up the land. There the landscape takes on a billowy appearance without distinct markers, and hence is often referred to as a trackless waste. Camels, because of their remarkable abilities to cross such areas, have aptly been called the ships of the desert.

Desert soils are commonly gray, but red soils also occur in a number of places, especially where the bedrock consists of red sandstone. They are usually rich in soluble minerals because the light rainfall which occurs results in little or no leaching. In shallow depressions, where water may gather following heavy showers, the soils are often so crusted with mineral salts that they are unproductive even under irrigation. Excess of sodium salts in desert soils is quite common and is responsible for much of the alkali so often encountered in desert areas.

In dry lands agricultural productivity is dependent chiefly upon stability of the soil and available moisture. Most desert soils are sufficiently rich in mineral content, but they are subject to wind erosion and are lacking in moisture. Soil stability and water supply are the requisites for dependable production

Agricultural industries.—There are two phases of agriculture—namely, grazing livestock, and, in the scattered oases, crop farming. Oases are water islands in the ocean of rock and sand Sources of water are varied—including springs and underground water in the wadis as well as the streams which flow from higher altitudes of heavier rainfall. The lowlands along the lower course of the Nile, where lands were formerly irrigated by overflow but are now watered largely by directing ditches, is one form of oasis, perhaps the most extensive as well as the most unusual type Local oases occur where springs are

found along valley sides or where shallow underground waters of the wadis sustain flourishing plant growth. In some sandy lowlands the ground water is so near the surface that it may be made available for plants if a few feet of the dry surface sand are removed In such manner true sunken gardens are produced, and the principal work of cultivation is to keep the inblowing sands from covering and smothering the vegetation



Courtesy, Payot, Paris

Fig. 209.—Oasis in the Sahara Desert, Souf region, southern Algeria. Note village in foreground and date palm groves in depressions. (From E F. Gautier *Le Sahara*)

Date production.—The principal commercial crop of the desert is the date The date palm is perhaps the oldest known cultivated fruit tree in the world. The early records of the Sumerian and Babylonian peoples in the Tigris and Euphrates Valleys show that it was widely tended by farmers several thousand years before Christ The technical name of the date palm is *Phoenix dactylifera*. Its optimum habitat is in warm lands with practically no rain, but where irrigation is possible

or where ground water is available While often referred to as a desert plant, it is a tree of the oasis rather than of the desert proper. It is probable that in Assyrian times some wise observer discovered the art of artificially pollenizing the date palm and thus achieved one of the earliest advances in scientific agriculture, an achievement which has continued to be of great importance ever since.

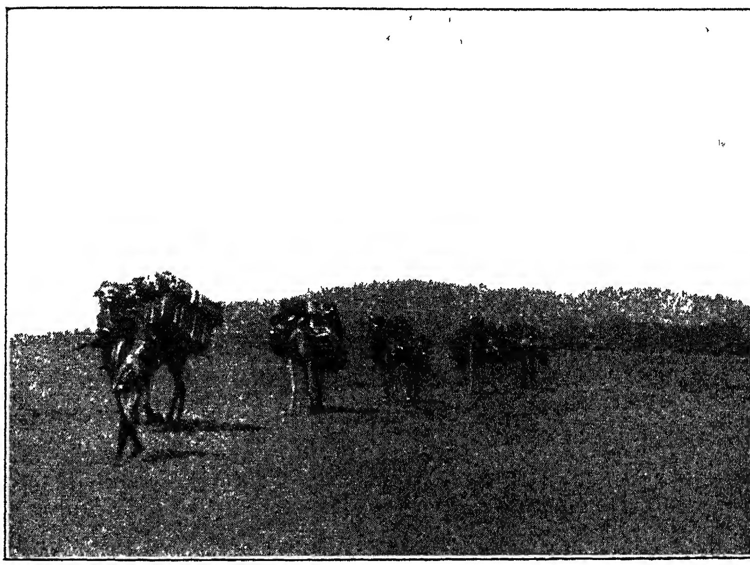
Date culture seems to have spread along the edge of the desert from southern Asia, across Africa, and much later to the deserts of Mexico and Peru. The Arabs introduced the palm and the art of its cultivation into Spain. The Spanish missionaries brought the seed with them to Mexico and California and under favorable conditions produced dates successfully, thus initiating a practice which has developed into a sizable modern industry

The centers of large-scale production of dates have, however, remained in the East In French West Africa dates are essential for the successful operation of the caravan routes. They make up the principal crop of the scattered oases and constitute the chief cash crop available for commercial purposes In Algeria, Biskra has become an important date market. In Arabia, the Sultanate of Oman, along the gulf of Oman, is another important date producing center The fruit is raised by irrigation along the coastal valleys in such abundance that it has become the leading export commodity The greatest source for the world's supply of dates, however, is Mesopotamia, the fertile, irrigated lowland along the Tigris and Euphrates Rivers There date trees line the Tigris as far up as Bagdad, and their product is valuable not only as a source of food supply but also as a cash crop. Bagdad and Basra are the chief export centers for the Persian and Mesopotamian areas.

The date has long been recognized as essential in the scheme of desert agriculture It is claimed that Mohammed was careful to teach this lesson to his followers, and that at one time he said to them: "Be good to your Aunt, the Palm, for she is made of the same clay that you are" They have been watchful ever since that, even in war, no matter how severe the conflict, the

date palm should not be injured Thus does the desert dweller pay homage to his staff of life, the date-palm!

Herding.—The native animal life of the desert shows specialization in the line of conservation of water similar to that of the plants. Animals are either slow moving, thick skinned and plated with bony armour, and furnished with extra water pouches, or they are so swift moving that they may quickly migrate from dearth of water to where it is plentiful.



Courtesy, Agence Genérale des Colonies, Paris, France

Fig. 210.—Camel transport in the desert of French Somaliland, Africa.

The horned toad and the Gila monster are examples of the former type, while the gazelle typifies the latter.

Among domestic animals the camel is the classic example of adaptation to the desert. He can eat coarse feed because he has lips equipped with skin that is nearly as hard and tough as the leather used for shoe soles; with those lips he can browse thorny bush and, in finger-like fashion, reach into crevices in the rocks for choice bits growing there. When he encounters a storm he can constrict his nostrils to small sized apertures wherein a sieve of hairs strains out sand and dust from the air

he breathes. He has eyelids equipped with double shutters to protect the orbs from the driven sands And for long journeys, when feedstuffs may be scarce, he has the humps on his back which serve as an extra feed supply upon which he may draw for bodily energy—a sort of extra gasoline tank for the animated desert motor! Is it any wonder that the camel has, through the ages, been man's chief reliance for transport over arid and semi-arid lands?

Not in the same class, but in contrast with the camel, the gazelle may be mentioned. Instead of humps on his back the gazelle has swift legs; he expects to bridge quickly the gap between scarcity and abundance of feed and water While the camel waddles, the gazelle flashes by The camel is the sturdy, lumbering truck depending on strength and reserve power to overcome the obstacles of desert distance; the gazelle is the flashy motor racer.

While the camel is the mainstay in large-scale desert transport, the flocks which constitute the productive basis of wealth are the sheep and goats In most desert areas, cattle will not prosper—the herbage is neither plentiful nor succulent enough for their needs. Sheep and goats have developed resistance to scarcity of water and tolerance for rough feeds far beyond that of cattle, therefore they accompany man farther into the lands of hardship and furnish sustenance where without them he could not survive.

Most land that is good for nothing else will, without man's intervention, grow some kind of plant that some kind of animal will eat. That is true at the edge of the desert, and so there the herdsman is at home On the comparatively fat land he raises sheep; on the leaner lands he must rely on animals that will utilize feeds so coarse that the sheep spurn them There the goat is the chosen one upon which man must depend We laugh at the goat for his great and varied dietary habits, but these are prized abilities in the land of little rain and scant, coarse herbage.

The animal industries consist of production of animals (1) for power and transport—camels, horses, and donkeys—and

inborn will to live; if they would live they must roam with the flocks that feed them. The laborer at the blast furnace, the farmer in his field, and the salesman at the counter carry on their duties in their different lines for the same reason—that they may live and enjoy the available comforts of life On the desert's edge the nomad follows the shifting rainbelt, adapts himself to the changing environment, and overcomes the obstacles involved in the struggle, proud in his own achievement and perhaps a bit scornful at the ease that he considers to be the lot of the sedentary dweller in contrast with the hardships of his own

The differentiation of labor is sharp· men are the herdsmen and the fighters, women till the soil at times when such occupation is possible, and they carry on the home industry. The flocks give wool and hides; these are the chief bases of the household arts Tannin-producing plants make possible one of the most skilled arts in the world, the making of Morocco leather. The fine and strong fleece of sheep and goats is the raw material for making the shawls and rugs of world wide fame The women, working patiently with hand spindles and looms, weave shawls and rugs noted for their durability and, far more important, also for their unexcelled artistic beauty The rugs thus made are objects useful in the domestic life of the nomads; they serve as floor covering, over the desert sands, and as couches and beds, taking the place of both mattress and cover. They combine utility with high value, little bulk, and ready mobility—desirable qualities for those who must always be ready to move on

The general tendency is for the desert dwellers to raid the cultivated agriculture at the desert's edge There are grown the grain and fruit that the nomads in their own habitat lack or can produce only in small quantities at cost of much labor. If the raids are prevented, as is the case when organized government is established, then at the desert's edge there become established market places where exchange of products is carried on, where the nomad and the farmer can trade to the advantage of both These markets quite naturally flourish best along the

major trade routes, and the cities which develop there become outfitting centers for the caravans which cross the desert expanses Such cities are picturesque in their variety of products and of peoples There the market places exhibit hides and grains, dates and melons, and on the streets are seen the keen-eyed traders, the sturdy farmers, and the dashing Bedouins.

Where people cannot depend on remaining in one place, individual property values cannot center upon land, flocks are usually the criteria of wealth. Real estate, as such, does not and cannot permanently belong to any individual but is often held to be the property of the tribe. Thus, the idea of property rights is one of continual vigilance, constant mobilization for defense or attack. The land belongs, for the time being, to the tribe that holds it and if necessary, fights successfully to keep it Barley, the product of most favored spots is the common breadstuff The desert nomad camps by the field because he must keep marauders away if he would eat bread In times of scarcity he exemplifies the axiom, "Self-preservation is the first law of nature" Since the democratic ideal of share and share alike would give none enough to live, he survives by taking all he can—those not successful in taking, perish

The occupations of men—herding, hunting, fighting—are dangerous, and hence mortality is high. Thus, there is a surplus of women in a social group wherein there is no opportunity of employment as stenographer, clerk, nurse, teacher, social secretary, nor any of the other numerous openings which are available for women in the more advanced civilized communities. If women would survive they must be attached to households, and so polygamy results, an adaptation to the conditions under which existence must be maintained.

On the whole, the desert's edge is a taskmaster with sharp requirements for those who survive. It leads to a race of strong, fearless, virile people. The men are polite, alert, and dignified. They are tall, handsome, lithe, and lean. These are the characteristics most conducive to success under the conditions which prevail where desert brown and grass green intertwine, because there man must be able to move quickly, to run and to

ride; in this contest lean men survive because fat men can neither run nor fight!

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CHAPTER XIX

The Regions of Dry Subtropical Climate and Their Characteristic Products

POLEWARD from the zone of tropical climates discussed in the preceding chapters lie belts where most of the months are warm but where frosts may occur during a short period commonly known as the winter season. Because of these occasional or brief periods of frost and because of lower annual temperatures than usually characterize tropical regions, these climatic belts are classified as *subtropical* The summers are long and warm; the winters are cool but not severe.

In the subtropical regions, temperatures show a marked seasonal rhythm during the year, and hence it is here that we first find the terms *winter* and *summer* in common use, a recognition of seasonal heat and cold quite in contrast to the wet and dry seasons of the all-year warm lands. As used in this discussion, subtropical climates are defined on the basis of the average temperature of the coldest month—namely, above 43°F. (6°C.) and less than 65°F. (18°C), with possibility of occurrence of frost. The warm limits of the subtropical areas may not have frosts at all in some years and rarely during any but the coldest month, whereas the cold limits of these areas may have frost-danger periods up to four months in length In other words, the annual frost-free period, often called the growing season in the different parts of the subtropical belt, varies in length from nearly a full year to slightly more than eight months.

Where subtropical climates are dominant.—As previously described (Chapter XVI), the tropical rainy zone is flanked on the north and south by belts wherein there is a moderate rhythm of temperature and where for a period a definitely dry

season prevails. In these belts, where tropical temperatures and seasonal rains prevail, marked differences in amount of rainfall are found between east coast and west coast locations Owing to the trade winds, prevalent from the northeast in the Northern Hemisphere and from the southeast in the Southern, the east-facing coasts are not dry, whereas along west-facing coasts, sub-humid to arid conditions prevail

Poleward from the equatorial belt, in the regions of subtropical climates, the annual rainfall along the east margins of the continents varies from about 35 to 60 inches, and in some places it is distributed quite evenly during the year Along the west margins of the continents, however, the annual rainfall is only from 10 to 30 inches, and it comes mostly during the low-sun period—that is, the cold season The former is usually designated as the *humid subtropical* type or cotton belt climate, whereas the latter is known as the *dry subtropical* or mediterranean type These two types may be considered to form a belt of transition between the regions of relatively stable atmospheric circulation and dependable weather of the tropics and those of unstable, often highly irregular circulation and changeable weather of the middle and higher latitudes

THE DRY SUBTROPICAL TYPE OF CLIMATE

The dry subtropical climate reaches its most extensive development along the margins of the Mediterranean Sea There west coast climatic conditions are dominant from southern Portugal and Spain to Palestine—an east-west stretch of more than 2,000 miles. Inasmuch as this extensive area early became a well-known center of civilization, and therefore its natural environmental conditions and its products were of widespread significance, the term *mediterranean* has been almost universally accepted to designate its general climatic characteristics. The other regions of the world where similar climatic conditions prevail are of smaller extent but nevertheless are important as seats of human activity. Such regions occur in southern Africa, southern Australia, central Chile, and southern California. In all these places we find the common characteristics of summer

drought, clear summer skies with richly colored sunsets, and rainy winters with frosts possible, and in many places probable, during a short period each year. (See map, Fig. 300.)

Temperature and rainfall.—The annual rainfall varies considerably in the different regions, but for the most part it is about 20 inches or less. Quite naturally the areas bordering the

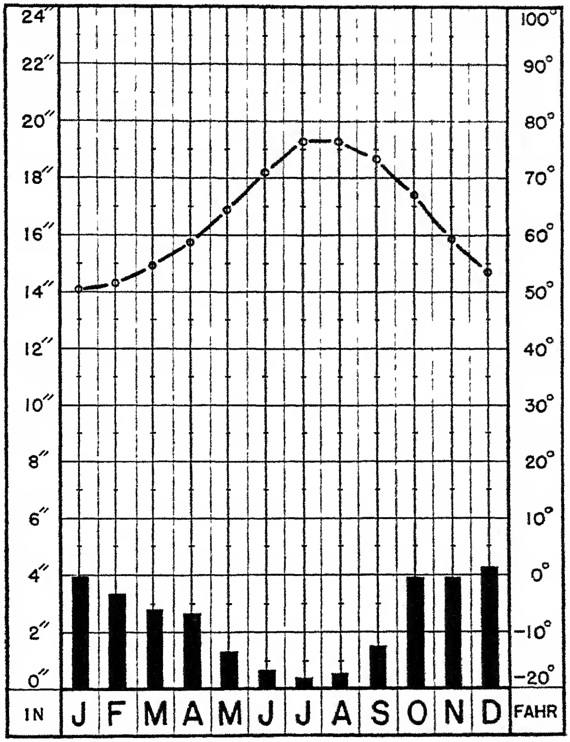


Fig. 212.—Dry subtropical climate. Average temperature and precipitation, Palermo, Sicily. Altitude 213 feet, total precipitation 30 inches.

tropical deserts have less rainfall than have the margins which border the humid regions of higher latitudes. For example, San Diego, California, has less rain than has San Francisco; Jerusalem has less than Rome. The total annual rainfall, therefore, varies from so little as to give rise to a distinctly semi-arid landscape to so much as to approach humid conditions. But, in

areas having this type of climate, winter rains and summer drought are prevalent everywhere

Somewhat similar temperature differences exist in these belts of dry subtropical climates. In the latitudes nearest the equator, frosts are rare, whereas in the latitudes farthest from the equator, freezing temperatures may occur during several months each year Differences in altitude are, of course, also important. Places that lie two or three thousand feet above sea level have distinctly colder winters than those at lower altitudes; and although the summer days may be nearly as hot in the former as in the latter, the summer nights are definitely cooler On the whole, therefore, temperature conditions within dry subtropical areas, while presenting considerable variety, all hold to the common standard of a short cool season and a long warm season. In most places the frostless period prevails during more than nine months of the year.

Winds.—The mediterranean type of climate is characterized by variable winds Equatorward the trades blow from easterly directions, while poleward the westerlies prevail Considering the Mediterranean lands and southern California as typical, we have to the south the lands where northeast winds are dominant, coming from over land areas and moving from cooler to warmer latitudes, they are drying winds, not rain carriers They thus give rise to the deserts of Sahara and Sonora. With the approach of summer the northeast trades move northward and carry dry conditions with them into latitudes beyond the all-year desert areas. The landscape becomes brown under the influence of cloudless summer skies and dry, steady, and often strong north and northeast winds Then as summer wanes and autumn approaches, the windbelts move southward again, and with the coming of winter the northeast trades are replaced by the southern margin of the Westerlies Under the influence of the low autumn and winter sun the land cools and, thus, as moisture-laden winds from the western oceans, or from the warm waters of the Mediterranean, sweep landward, condensation takes place and clouds and rain result. The summer

brown is replaced by winter green and the year's cycle is finished.

Quite naturally, the poleward areas have stronger westerly winds in winter than do those nearer the equator. Thus, the coasts of southern Europe are more copiously watered than those of northern Africa; the same is true for the central and southern portions of the California coast. In general, more rain falls on the higher slopelands facing the sea than on the lower lands; the rain and snow caught on the mountain slopes are the chief sources of the water available for irrigating the dry, adjacent lowlands

In addition to these broad wind movements there are local winds of well-recognized importance, this being markedly true in the Mediterranean lands where conspicuous gaps in the long northern mountain barrier exist. The Rhone Valley serves as a great gate through which a strong current of cold air, known as the *mistral,* occasionally sweeps with storm-like violence from the Central Plateau of France to the Mediterranean. Northeast of Italy a similar gap in the Alpine mountain barrier permits a violent wind movement, called the *bora*, to sweep down from high plateaus to the Adriatic. These winds, the mistral and the bora, are most likely to occur in winter when high pressure areas have moved into continental Europe and low pressure areas have taken a southerly course into the Mediterranean. In earlier times, when vessels were smaller and depended entirely upon sails for power, these winds were dreaded by navigators and were a real menace to commerce. Even now they have importance, particularly in navigation of the air. When the Graf Zeppelin made its first attempt to fly the Atlantic and, on account of some slight difficulty, decided to return from the Mediterranean up the Rhone Valley to its base at Friedrichshafen, it encountered the mistral blowing with such force that progress against it was impossible. Only through most skillful navigation did Commander Eckener succeed in bringing his great craft out of the main current and finding shelter east of Marseilles, where the western Alps shut out the

north winds and give rise to the well-known sunny Riviera of France and Italy.

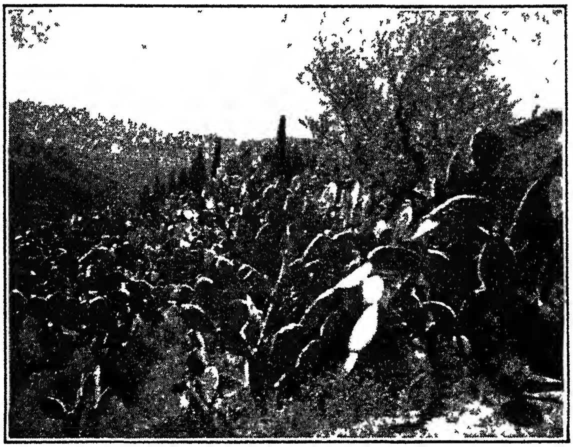
Inasmuch as the dry subtropical regions generally adjoin deserts along their lower latitude borders, they are occasionally subject to scorching winds which originate in those hot, dry lands When the pressure over the Mediterranean is markedly lower than over the Sahara, hot south winds may sweep across the northern border lands of Africa into the Mediterranean. The approach of these winds is ordinarily heralded by a haze over the southern horizon which gradually overspreads the sky; the air becomes calm, the ocean surface almost glassy smooth; then the storm breaks, suddenly filling the air with dust and sand and lashing the sea to fury. The duration may vary from a few hours to two or three days During this period humidity is sometimes less than 10%, temperatures are high, and plant and animal life suffer severely When these storms set in during the blossoming time of olives, vines, or other fruits, the year's crop may be ruined The names given these storms vary with different localities They are known as the *sirocco* in Sicily and southern Italy, as the *leveche* in Spain, as the *samoon* in North Africa and Syria, and as the *Santa Ana* in southern California. In general, sirocco is probably the most widely used term for these winds from the desert which blast the dry subtropical areas

The world renowned colorful sunsets are another feature characteristic of dry subtropical lands. The long summer droughts and the variable shifting winds cause fine dust to be suspended in the air up to great heights. While this is true in all arid regions, it is of course most markedly so where the dust is very fine, as with the weathered volcanic areas of Italy Furthermore, along the coast of Italy the warm Mediterranean serves as a great mirror to bring color values out in marked degree That this is of real economic value is attested by the advertising appeal so effectively used by tourist agencies

Native vegetation.—It is well recognized that climatic conditions are most clearly reflected in the native plant cover of a land area The characteristics of the mediterranean climate

which most profoundly affect the vegetation may briefly be summarized as follows (1) rain falls freely in the winter half year, especially on west-facing slopelands and in the parts of the subtropical belt farthest from the Equator; (2) summer is a period of drought which may be partial, or so complete that some months are entirely rainless; (3) the annual range of temperature is moderate, so that typically the winters are mild and the summers are quite hot

The most obvious effect of these climatic conditions is to produce a landscape of brilliant green in winter and of subdued



Courtesy, Italian Tourist Information Office, New York.

Fig 213.—Xerophytic vegetation on Sicily, Italy.

brown to yellow hues in summer. In the lowlands the winter cold is rarely severe enough to stop the growth of perennials. Most trees and shrubs are evergreens which are able to grow during the winter season. During the summer months, however, they are exposed to the burning sun and therefore must protect themselves against extreme loss of moisture. As a result, most evergreens have hard, leathery leaves, often thickly set with fine hairs further to restrict evaporation; or, as is the case with the conifers, narrow needle-like leaves prevent too great a loss of moisture. Many perennials of the deciduous type have only very inconspicuous leaves, green stems and long

thorns taking over their function. Annuals can exist only during the rainy season. Grasses and low flowering plants begin to grow in the fall, either from bulbs or from seeds; they bloom in April and May and then wither and disappear with the advent of the dry, hot summer season

Forests are scarce in the lowlands and flourish most generally on the higher slopes, especially on those exposed to moisture-bearing winds The timbers used by the builders of Solomon's Temple and for the construction of boats by the sturdy Mediterranean seamen were obtained from such localities. But since most people live in the lowlands, where timber is not readily obtainable, stone and sundried brick have long been the common building materials This is particularly true of the Mediterranean countries. In the United States the regions having a dry subtropical climate are smaller, and modern transportation facilities make lumber so easily available that wood is quite generally used for construction purposes

Much more characteristic and far more widely distributed than the high forest are the thickets or scrub-forests, which consist of scattered trees and dense masses of shrubs with much undergrowth Vines, many of them thorny, bind the whole together in a tangled, prickly, almost impenetrable mass. These thickets are common from Spain to Greece, and similar aggregates of thorny bush and vine are found in all other parts of the world having the dry subtropical climate. Since this type of vegetation reaches its optimum development in Italy, the name *macchia* has been accepted to designate it, although the French term, *maquis*, is the form in which the original Italian word has been adopted into the English language. The maquis is the source of the bundles of sticks peddled as firewood in the streets of Mediterranean cities and villages. Charcoal has long been made out of some of the larger stems and branches.

But there is a lower and even more scraggly type of vegetation than the maquis. Inasmuch as drought conditions are prevalent at low altitudes, and such rain as falls often comes as heavy showers, the steeper slopes have thin soil, not very retentive of moisture These slope lands are quite extensive and,

especially in the Mediterranean countries, support a sparse vegetation made up of small, drought-resistant bush. The Germans call these forms "half-shrubs," an aptly descriptive term because they are somewhat of a half-way type between herb and shrub. The commonly accepted term is *garigue*, the French term used for this vegetation on the limestone slopes of southern France.

One might at first think that the garigue and the maquis can have little value. This is hardly the case, however, because even where grass is scarce, sheep and goats can thrive on coarse forms of vegetation Sheep do quite well where the garigue and maquis are fairly open; where the vegetation is more tangled and coarse, goats are able to find nourishing feed Through its fodder value this thorny, inhospitable vegetation contributes directly to the kid slippers and gloves for the ladies of Paris, London, and New York Furthermore, the plants of this semi-desert type have an abundance of blossoms which are harvested by bees, a significant fact now, but even more so in earlier times when honey was the only sweetening available.

Another element of the vegetation landscape that deserves mention is the dwarf-palm This is characteristic of the Mediterranean countries, especially those of northern Africa, and it has been widely introduced elsewhere. The mediterranean climates thus have considerable variety of vegetation types, varying from the mountain forests of broadleaved trees—such as oaks, chestnuts, needle leaved pines, and narrow-leaved cedars —to the semi-desert shrub and dwarf palms. The two most widespread and typical phases, however, are the maquis and the garigue.

Soils.—Topography is an important factor in soil development in all the regions having dry subtropical climates. As a map readily reveals, these regions are characterized by steep mountain or plateau slopes and relatively narrow plains in the valleys and along the coasts. Extensive areas of land with low relief are lacking. The topography may be generally described as consisting of steep-sloping uplands, flanked by strips of detritus-built plains at the bases of the slopes. The topographic

conditions imply eroded or skeletal soils on the slope lands and soils of depositional origin on the low plains. Active erosion tends to prevent the development of normal mature soils on the slope lands, and active deposition by wind or water prevents their development on the lowlands

Because of the low rainfall, leaching is slight and the soils in most cases are of the pedocalic class The prevailing high temperatures are conducive to weathering, and therefore the soils are well supplied with the products of rock decay—namely, clay and soluble mineral salts Humus, however, is not abundant as a rule, a condition directly attributable to the sparse native vegetation and a flora consisting of trees and shrubs rather than grass. Since the colors are brown and red, the terms brownerths and brownish rederths are used to designate these soils

Viewed broadly, the immature lowland soils are highly productive. They represent an accumulation of the fine particles which have been washed down from the slope lands and deposited without much loss of soluble mineral content, either along the stream valleys or as piedmont plains at the foot of the mountains There the native vegetation flourished more abundantly than on the higher and drier slopes, and the decaying organic matter served to enrich further these immature lowland soils. Water is the great need. Where this is supplied, as in southern California or in the irrigated valleys of the Mediterranean lands, abundant harvests of grain and fruit result

The soils of the slope lands, on the other hand, are generally thin and poor This is particularly true where tillage has long been practiced In some parts of Greece and Italy the soils on steep slopes are protected from erosion by an intricate system of terraces Thus, productivity has been maintained, but only through the increasing labor of many generations of farmers. Viewed as a whole, the slope lands with their skeletal soils and their scanty vegetation are best adapted for use as grazing lands In the most favored locations this pasturage will support cattle; in the more rugged sections, where only coarse herbage thrives, goats are able to maintain themselves quite well; else-

where sheep raising is the most economic phase of the livestock industry.

Agricultural industries.—By some the dry subtropical climate has been termed the "climate of achievement." The lands around the Mediterranean have, from very early times been centers of culture, and from there our boasted modern white civilization has sprung. Without making any claim that the early development of civilization in this area is due entirely to climatic conditions, it cannot be denied that in the Mediterranean lands substantial production has always been possible, but such production has demanded both effort and thought. The *morrow*, the season of little rain, had to be considered, and thus methods of tillage to conserve moisture resulted, drought-tolerant crops were selected, irrigation systems were devised, and schemes of grain storage were planned to offset lean periods These are impulses toward coöperation and progress, and there is little wonder that the people in such areas were stimulated to mental as well as to industrial activity, often developing a higher organized society.

Two general types of land utilization characterize the agriculture of the dry subtropical lands—namely, the extensive, dry-land type and the intensive irrigated type The former includes grazing and grain and fruit culture. Wheat and barley are the most important grains, while the vine, fig, and olive lead among the fruits. The latter type includes the moisture loving crops, such as give high returns per acre, the principal ones being corn, rice, vegetables, and citrus fruits These two types of agriculture are in sharp contrast, the one involving extensive land holdings and the other intensive use of small acreages The need for production tends toward full use of water available for irrigation; expansion of irrigation farming is halted by scarcity of water rather than by lack of land or markets

Animal industries.—Since summer drought and winter rains are more conducive to bush and shrub than to grass, the livestock industries have centered about burros rather than horses, and goats rather than cows. Sheep and goats are the mainstays

of the pastoral pursuits. Where forage is relatively abundant and pastures are open, sheep predominate Since sheep are timid, defenseless creatures, the herdsman's watchful care has always been essential Out of this has come the symbolism of the shepherd in sacred story and song—a symbolism which is beautifully expressed in the religious rites of modern church worship throughout Christendom. The mild climate wherein forage is fairly plentiful but grain feeds are scarce seems to have been conducive to the development of breeds of sheep small in size but of superior quality of wool. The Spanish Merino have world wide renown in this respect.

Where forage is scarce, topography rugged, and the vegetation harsh and unpalatable, the sheep give way to their more active cousins, the goats Thus, in the eastern Mediterranean lands especially, and in the less favored areas elsewhere, we find the goat, man's most tolerant and persistent producer The world's foremost center of production of goat skins is in the Mediterranean lands of southeastern Europe There, where neither grass nor grain is abundant, the goat exists, furnishing food for the local population and providing the finest hides out of which gloves and shoes are made to be worn by the titled and untitled aristocrats of the world's fashion centers.

Another phase of the animal industries that deserves attention is poultry raising. In these areas of nearly all-year growing season with prevalent low humidity, the poultry industry has a high place. The Mediterranean breeds of chickens are noted for their hustling abilities, their agility rather than size. The natural habitat, with its green forage available most of the year, with its seed-bearing bush and flitting insect life, has been conducive to the development of quick-moving kinds of poultry From these lands the well-known Leghorns and Minorcas have sprung, small agile birds quite in contrast to the heavy, ponderous Asiatics. The Mediterranean breeds mature early and make high scores in egg laying. These qualities have placed them in favor as food producers, and are important factors in accounting for the well-known factory-type poultry farms of southern California

Grain agriculture.—Winter rains and summer drought favor early maturing crops, hence, as far as cereals are concerned, small grains rather than corn are characteristic of dry subtropical regions. Hard winter wheat and barley are the foremost cereal crops, the former a bread grain, the latter chiefly used as a feed grain but locally important for food. The Mediterranean lands have always been noted as wheat producers, and in earlier times the attempts to insure wheat supplies were often the dominating motives in commercial and even in military contests. Control of the fertile valleys of the Nile, of Greece, Italy, and Spain was sought largely because of their value as wheat lands.

Durum wheat, popularly known as macaroni wheat, is the type most characteristic of the dry subtropical climates. This is hardy and drought-tolerant, and so it is well adapted to areas where there is little summer rainfall. Although its flour is not well adapted for bread making, it makes a very palatable and highly nourishing foodstuff when formed into the tubular pastes known as vermicelli, spaghetti, and macaroni. The art of making these pastes is of Italian origin but has spread to nearly all lands. The Italians have taught practically the whole white race to enjoy their favorite dish, spaghetti.

FRUITS AND VEGETABLES

The dry subtropical climates are centers of production of early vegetables for northern markets. There is an increasing shipment of early fruits and vegetables from the valleys of northern Africa and southern Europe to the centers of population in northwestern Europe. In the United States the shipments of melons and head lettuce from southern California to the northern and eastern markets call for trainloads of freight sent across country at express speed. There is an increasing shipment of so-called "promeurs," early potatoes and vegetables, from northern Africa, Spain, southern France, and Italy to the areas of dense population in northwestern Europe. Central Chile is profiting by a growing trade in fresh fruits and melons which can be sold in the northern markets in winter when local produce is unobtainable. Early markets are always

relatively high priced markets Thus, the ability to provide out-of-season produce is of distinct advantage to the centers of production, while it adds materially to the standards of living in the areas served. Surely the mutual advantage of trade to both seller and buyer is well illustrated in this traffic!

On a large-scale basis, however, the dry subtropical lands are the world's principal areas for the production of olives, figs, currants, grapes, prunes, and citrus fruits. The mild winters and warm, sunny summers are favorable for these fruits, which are quite tolerant of little moisture during the latter part of the growing season From a world point of view the Mediterranean lands rank foremost in the production of olives, figs, currants, and wine grapes, while California holds first place in prunes, raisin grapes, and citrus fruits Grapes and citrus fruits are of economic importance in each of the other dry subtropical regions as well—namely, in South Africa, central Chile, and southern Australia.

Olives.—The olive appears to have been native to southwestern Asia and to have been one of the trees earliest cultivated by man Records indicate that it was grown on the island of Crete before 1500 B. C, and that it was growing on the hills of Sicily about the same time The gift of the fruit was a token of peace among the barbarians of early times, and the importance of the olive in the diet of the people of eastern Mediterranean lands is symbolized by the frequent references to it found in sacred literature

The olive industry is chiefly dependent upon the one species of tree, the *Olea europea* or European olive The tree is noted for its ease of propagation, its hardihood, its heavy yield of fruit, and its longevity; furthermore, it does not need irrigation, and therefore in the Mediterranean region olive groves are generally found on the hillsides or in stony parts of the plains. In many districts olive trees are interplanted with grape vines, or even with wheat By the eighth year an olive grove should be in profitable production, furnishing 20 to 40 gallons of olives per tree, and should continue so for many years. Olive trees more than a century old are common in the Old World,

and many instances are known where the age is supposed to reach 300 years or more

The harvest of the olives comes at the beginning of the winter rains, in the Northern Hemisphere usually in November. High quality olives are picked by hand and kept scrupulously clean. In many of the older producing sections such care is not practiced—the fruit is shaken from the trees by beating the branches with poles, and the olives are picked from the ground

Courtesy Department of Agriculture, Spain, and American Consular Service

Fig. 214.—Olive groves on high slope lands south of Cordoba, Spain.

in more or less bruised condition. This lowers the quality of the oil and causes undesirable flavors to develop.

While many olives are sold for table use, the chief purpose of production is to obtain the oil. Olive oil is expressed from the fleshy part of the ripe fruit; the yield of oil from a well grown mature tree 15 years old should be from 200 to 250 pounds a year. The quality of the oil depends more upon the care with which the fruit is handled than upon the soil or climatic conditions under which the olives are produced.

Olive oil is widely used in the Mediterranean countries be-

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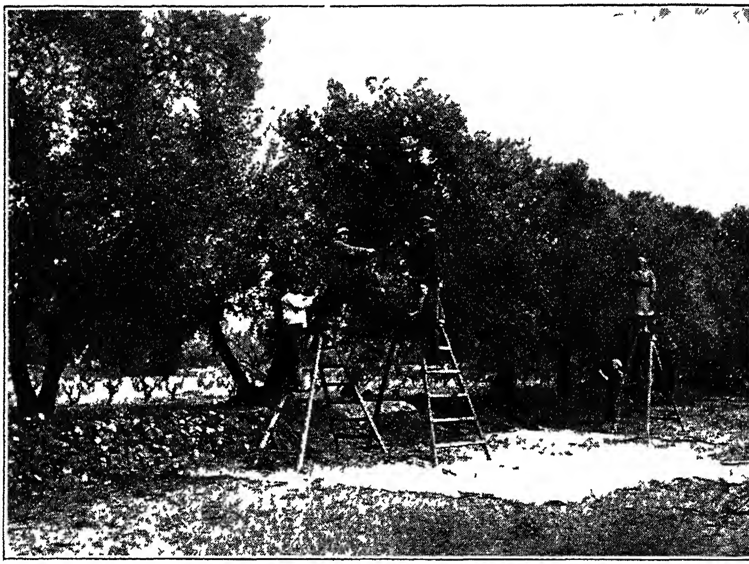
cause of the scarcity of animal fats Where climatic conditions are unfavorable for the production of feed grains and grass, large scale production of cattle and hogs is impossible Where butter and lard are scarce, olive oil is a highly satisfactory substitute. Furthermore, where summer heat and drought prevail, the atmospheric conditions tend to irritate the skin; hence the need for oily ointments, a need which olive oil has been called to fill since earliest times



Courtesy, Department of Agriculture, Spain, and American Consular Service

Fig. 215.—Picking olives in Spain. Notice the canvas spread to catch falling olives.

No wonder then that the olive is so important in the Mediterranean lands. There the areas of dry subtropical climate are most extensive, people most numerous, and hence demand greatest. Spain, Italy, and Greece, in the order named, produce more than 80 per cent of the world's commercial olive crop; other important producers are Tunis, Portugal, Algeria, and Syria, all of them Mediterranean countries California is the only other important center of olive production. The quality of the output there is of the best, but the quantity, though increasing, is less than five per cent of the world's total Inasmuch

as California has much land well adapted to olive growth, and since the methods practiced insure a superior quality of product, a substantial increase may be expected in the next quarter century.

Figs.—The fig tree appears to be indigenous to Asia Minor and Syria, and various species are found growing wild in most of the Mediterranean countries. Inasmuch as it is frequently referred to in Hebrew scriptures, the fig was probably one of the earliest cultivated fruits of the eastern Mediterranean lands. It was one of the staple food articles of the Greeks, and it plays an important role in old Latin myths.

The well-known fig of commerce, *Ficus carica,* is a small tree reaching heights of 18 to 20 feet, with rough branches, palmately lobed leaves, and compound fruits. While it is widely grown in the tropics and subtropics, the principal centers of commercial production are in the Mediterranean countries, southern California, and southern Texas.

Although there are numerous varieties, the Smyrna fig is of outstanding commercial importance because of its flavor, largely attributable to its numerous fine seeds. It depends on fertilization by the fig wasp (Bastophage grossorum), an insect which spends part of its life cycle in the fruit of a wild variety known as the Capri fig. The wasp emerges from the Capri fig and enters the opening in the end of the Smyrna fig, carrying upon itself a portion of Capri fig pollen which thus fertilizes the Smyrna fig, causing normal development of seed, flavor, and aroma. Two Capri trees for each hundred Smyrna trees have been found adequate to insure the carrying out of this somewhat complicated but essential process of pollination. When Smyrna figs were first introduced into California the trees grew successfully and blossomed, but failed to bear fruit Only after the role of the fig wasp had been studied in Asia Minor, and the Capri fig and wasps had been obtained, did fig culture become a success.

Fresh figs are a favorite fruit in the producing districts, but the trade deals chiefly in the preserved or dried forms. Turkey leads all the countries in production. Figs are grown extensive-

ly along the coast of Asia Minor, the chief shipping port being Smyrna, whence the commercial name for the variety is derived. All the other Mediterranean countries are important producers and most of them are also important exporters, this being particularly true of Greece, Italy, Spain, and Algeria. In the United States, California leads in output, but in recent years southwest Texas has so increased its plantings that it bids fair to become an important competitor. If so, Texas will have the distinction of being the only prominent center of commercial fig production located outside of the dry subtropical regions.

In the imports of figs into the United States, Turkey holds foremost place by a wide margin, furnishing ordinarily about 65 per cent of the total. Greece is second with about 20 per cent, and the remainder comes from the other countries along the Mediterranean. With increasing domestic production the trend is toward a declining import trade, unless a marked increase in consumption should occur. The present tendency, however, seems to be to sustain domestic prices by means of import duties, a practice which does not lead to increased consumption.

Dried fruits.—Sun drying of fruits as a means of preserving food has been practiced for countless ages. Nature does this in the ripening process of grains, and man early learned to imitate nature in the case of a number of fruits and vegetables. Until methods of canning and refrigeration were devised, drying was the prevalent method of preserving fruits. The countries of dry subtropical climate were at a distinct advantage in this practice because of their variety of fruits with high sugar content and because of their dry, cloudless summers favoring the sun-drying of fruit. The principal fruits preserved in this way were prunes, currants, and raisin grapes; and in spite of the tremendous development of canning and refrigeration, these still remain in high favor and are produced on such a scale as to be of great commercial importance.

Prunes.—While plums occur in many countries and climes, only a few varieties are characterized by such firmness and

sweetness as to cure instead of spoil under natural drying conditions The term *prunes* is applied technically to plums which have been dried without removal of the seed; popularly however, the term covers also the fresh fruit in the districts where the general practice of drying into prunes prevails Prunes grow best along the cool and moist margins of the dry subtropical climates, somewhat in contrast with the figs and olives, which do best in the warmer and drier sections Southern

Courtesy, Chamber of Commerce, San Jose, California

Fig. 216 —Drying prunes, Santa Clara County, California.

France, especially the district near Tours, was formerly the world's foremost prune growing center. Supremacy in Europe has, however, passed to Yugoslavia. Although a large percentage of the fruit is used in the manufacture of brandy and jam, the exports of prunes in some years have exceeded 100,000,000 pounds, most of them going to the neighboring countries

As late as 1890 the United States imported more than 60,000,000 pounds a year, chiefly from France. Plantings in California, especially in Santa Clara county, south of San Fran-

cisco, have proven so successful, however, that it has become the world's leading prune producing center. Prunes have also been found to grow well in the mild climates of Oregon, Washington, and parts of Idaho A number of varieties are grown, thus making fresh fruit available for the market from June to November as well as providing freshly dried fruit in all months of the year This development has changed the United States from the role of importer to that of exporter. In late years prunes have gained first place in our exports of dried fruits, the quantity exceeding 230,000,000 pounds Our principal markets are Canada and the countries of northwest Europe, but it is a noteworthy fact that American prunes are sold in nearly every market of the world

Currants.—Quite in contrast to the wide distribution of plums is the extremely limited distribution of currants These are found in continental Greece and on some of the outlying islands. The name *currant* is a corruption of Corinth, the seaport long famous for exports of this particular dried fruit. The currant is in reality a form of seedless grape The total annual production of Greece is usually between 125 and 150 thousand tons, and currants account for 25 to 30 per cent of the total exports of the country. American imports of currants range from 7 to 10 million pounds per year, nearly all coming from Greece Although Greece still holds undisputed first place in the world's currant industry, production is increasing in California and southern Australia, and within a decade or two competition from these centers is likely to be a factor of considerable importance in the trade

Grapes.—All regions having the mediterranean type of climate are noted for their grape culture. This holds as true for South Africa, central Chile, southern Australia, and California, as for the older and more extensive area bordering the Mediterranean Sea In all of these countries the production of grapes for table use is important, although not rivalling the output of wine grapes Southern Spain has long been famous for its grapes of such high keeping qualities that they are available for table use late into the winter. Through modern methods of

storage, fresh California grapes are on the market during most months of the year.

Raisins, made by drying special varieties of grapes, are among the staple exports of most regions having a dry subtropical climate The center of output of raisins, as with prunes, has shifted from southern Europe to California. Machine methods of cleaning and drying have largely, although not entirely, supplanted the older method of sun-drying Eastern Spain, with Almeria as the centuries-old notable export center, still has great importance in the raisin trade; and Sultana raisins, made from a variety of richly flavored seedless grapes grown along the eastern Mediterranean, hold high place in European markets. The Sultana grapes are grown also in Greece, on the islands of the Aegean, and in the southwestern Asia Minor, where Smyrna is the export center. Spain and Greece are the leading countries of the Old World in raisin exports Supremacy in raisin production has, however, passed to California. The significance of this change is shown by the fact that prior to 1890 the United States imported from 35 to 40 million pounds of raisins per year, whereas in 1930 only 1,834,000 pounds were imported, contrasted with exports of 123,000,000 pounds. Spain and Turkey are the only important sources of American imports, while the exports go to nearly every country in the world The leading foreign markets, however, are the United Kingdom, Canada, Germany, the Netherlands, and Sweden. Future development of the California raisin-grape industry is dependent on markets, because sufficient land is available to provide several times the present output

The wine-making industry —Grapes appear to have been indigenous to southeastern Europe and southwestern Asia. Their utilization for the manufacture of wine is one of the oldest known industries, and Old Testament references give evidence of the high favor in which wine was held by ancient peoples This is more easily understood if we bear in mind that the Mediterranean countries have rather low winter rainfall and prolonged summer drought. Good water is not readily obtainable even now in many places, and in earlier times this was

more markedly true. Wine was a thirst-satisfying drink that did not convey disease and that could readily be stored for use when needed The scarcity of good drinking water, still prevalent in parts of southern Europe, is an important factor in making that region so prominent in wine production.

From an American point of view the amount of wine produced by the leading Mediterranean countries appears enormous. In recent years the output has mounted to over 4,000,000,000 gallons annually, France alone accounting for from one billion to nearly one and three-quarter billion gallons per year. Italy is only slightly below France, and the other countries of high rank are Spain, Algiers, and Portugal. Although approximately 75 to 80 per cent of the wine is consumed in the countries where produced, it is nevertheless an important export In Spain and Portugal the wine exports are among the principal sources of national income. Northwest Europe and Canada are the leading markets, but Mediterranean wines are shipped to nearly all other parts of the world as well.

The other regions of dry subtropical climates each have wine industries, but none of them have approached the Mediterranean countries in economic importance This may be due in part to the fact that wine making depends on skill, and that this skill has not been so highly developed in the newer centers Another factor of major importance, however, is that of reputation; the high reputation acquired by the Mediterranean countries through centuries of wine making now serves as an economic asset of tremendous value Other regions will find this a difficult hurdle to overcome in open competition.

The citrus fruits.—The orange, lemon, lime, and grapefruit or pomelo, together with several other citrus fruits less widely known, have been important commercial products of the subtropical lands. In a way they may be said to be commercially the advance guard of the tropical fruits to enter cool climate markets. The two qualities which are most effective in promoting trade in citrus fruits are, first, their acid flavor combined with pleasant taste and health-promoting qualities and, second, their thick, oily, and bitter skins, which serve to pro-

tect them from insects and from bruises in shipment.

The citrus fruits are native to warm subtropical lands of considerable rainfall, southeastern Asia being the ancestral home of most of the species, although the lemons and limes appear to have been native to India. From southern Asia sweet oranges were introduced into the Mediterranean countries by the Portuguese in the latter part of the fifteenth century, and thus a beginning was made of an important and enduring industry From Spain the citrus fruits were carried to the New World, and their cultivation has expanded so that they are now grown in nearly all of the tropical and subtropical lands of the world.

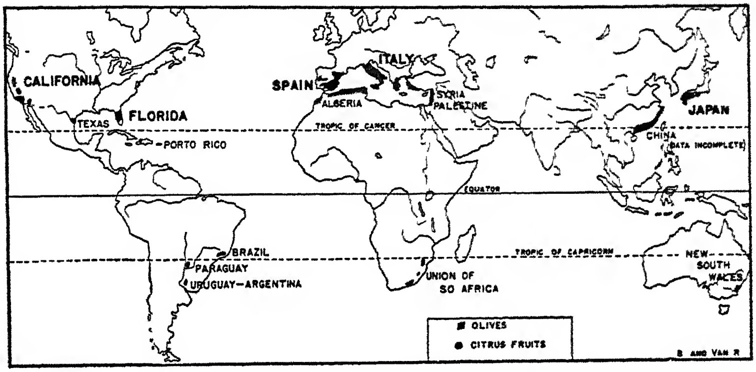


Fig. 217.—Principal centers of production of citrus fruits and olives.

Citrus fruits are produced most successfully in areas where warm temperatures and a high percentage of sunny days prevail. Their native habitat in southeast Asia is indicative of their moisture-loving propensities. The dry subtropical regions lack an important requirement—namely, a sufficiency of moisture during the warm season. Where water can be supplied by irrigation, optimum conditions for growth are provided. The abundant yield and great accessible markets give the economic rewards upon which the industry prospers Inasmuch as oranges and lemons are the most typical of the citrus fruits and are of leading commercial significance, the detailed discussion will be limited to them.

Lemons.—The lemon, *Citrus limonum,* is probably indigen-

ous to the valleys of western India, and appears to have been grown in orchards by the Romans as early as the second century A D. It probably was the first of the citrus fruits to be introduced into Europe.

The lemon tree does not grow tall; it rarely reaches a height of more than 10 or 12 feet. In general, a mild climate with much sunshine, fertile soil, an ample water supply, and without freezing temperatures, are the essentials for successful lemon production. In southern California a supply of irrigation water to a depth of 12 inches a year, to supplement the natural rainfall, is deemed necessary for the lemon groves.

The two most-feared dangers are fungus diseases and frost. A fungoid disease has caused serious losses to the lemon growers of Italy. To prevent this fate the growers in California take great care to insure ample light and air to all parts of the tree. Pruning is scientifically done, trees are spaced so as to avoid over-crowding, and spraying is carried on methodically to destroy insects and to limit fungi When danger of freezing is imminent, oil-burning heaters are placed throughout the groves, and if possible a liberal supply of water is run into ditches and laterals These operations involve care and cost, but their results have been such as to justify them.

The healthful qualities of lemons have long been recognized The British Merchants Shipping Act of 1867, still in force, specifies that every British ship destined for countries where lemon or lime juice cannot be obtained must provide a sufficient supply to give one ounce of such juice daily to each member of the crew. This measure was intended as a preventive of scurvy; its effectiveness is now known to be due to the high vitamin content of the juices prescribed.

The increasing competition with other citrus fruits has produced a stationary situation in the lemon industry. The lemon groves of Italy, Spain, and the United States are nearly all in bearing and there is no apparent tendency toward increase in plantings In California less than five per cent of the lemon acreage is non-bearing. The crop is picked during the winter and spring months and stored to meet the heavy demand of the

summer season. The volume of lemon imports, largely from Italy, varies inversely with the size of the domestic crop. In recent years imports have varied from about 600 000 to 1,000,000 boxes, a marked decline from about 2,500,000 boxes, the average import of the 1909-1913 period

Italy is the world's principal lemon producer, with an annual crop of nearly 12,000,000 boxes, 90 per cent of which are grown in Sicily The United States holds second place with an annual production of about six to eight million boxes of 360 to 420 each. Most of the American lemons are grown in southern California. Spain ranks third with about 1,500,000 boxes annually. Small amounts are produced in each of the other Mediterranean countries and in Australia, New Zealand, South Africa, and Florida, but in none of them on an export basis Although increasing production is reported from the minor centers, there is little reason to believe that the world situation will be appreciably altered thereby. Italy, southern California, and Spain seem likely to remain the chief sources of supply for the world's lemon trade

Oranges.—The orange has become widely grown in tropical or subtropical lands the world over In some places, as, for example, in Paraguay and in parts of Brazil, the natural conditions are so friendly that the plant grows wild. Notwithstanding that they are widely distributed in some of the warm humid lands, especially in Japan and southern China, the centers of commercial production are largely within the regions of dry subtropical climates, each of which has an important orange industry.

The growing of oranges has long been important in the Mediterranean countries because climatically they furnish a favored habitat for such a frost-sensitive crop Large export markets are provided by the millions of people of northern and western Europe who are readily reached by numerous railroad and steamship lines.

Oranges are of many varieties but fall into two principal classes: the sweet and the bitter. The former is by far the more important and is the kind generally referred to. The bitter

orange is grown to some extent in Spain, chiefly for its rind, which is used in making English marmalade and in the manufacture of a liquor known as *curaçao*, so named after its place of origin, the largest island of the Dutch West Indies. There are many kinds of sweet oranges, but their ripening periods are such as to divide them into two main groups: winter and summer oranges

Orange production Mediterranean countries.—Spain leads all countries in exports of oranges and is a close second to the United States in production. The producing districts lie mainly along the Mediterranean coast, the province of Valencia being the leading center. Most of the Spanish oranges move by water to the countries of western Europe, but the rail shipments across France to central Europe are increasing Northwest Europe is the principal market, the United Kingdom and Germany taking about 60 per cent of the total exports, while France, Belgium, the Netherlands, and the Scandinavian countries take lesser amounts Shipments of Spanish oranges begin in November and continue heavy until May or June, after which the movement is negligible

The total production of oranges in Spain ranges from 32 to 42 million boxes (70 pound equivalent) per year. Present indications are that Spain's leading position as an orange-exporting country, furnishing nearly two-thirds of the total entering international trade, is assured for years to come

Italy ranks third in production but second in exports, the total crop being between 8 and 9 million boxes, of which 35 to 40 per cent are exported. Lack of standard methods of grading and boxing formerly handicapped the sale of Italian oranges in foreign markets, but great improvement in these particulars has been made in late years. Italy's location is advantageous in respect to the markets of central and eastern Europe Production seems to be about stationary, no marked changes in output having been reported in recent years

Palestine has lately become an important producer of oranges. The annual exports now exceed 2,500,000 boxes, and it is estimated that within a few years, when the young plantings

come into full bearing, they may be increased to 6,000,000 boxes.

Less important producers of oranges are Algiers, Syria, Greece, Morocco, Portugal, and southern France. As a whole, the Mediterranean region promises to hold its place as the world's foremost citrus fruit producing area, favored as it is by soil and climate and by ready accessibility to the world's greatest markets.

South Africa and Australia.—Although the quantities are small when compared with the Mediterranean region, oranges have been produced on a commercial scale in the Union of South Africa and in Australia for a number of years. Recent trends have been moderately upward, and plantings, not yet in full bearing, give promise of production of 2 to 3 million boxes in each of these countries. The British Isles provide the most important market for the Union, while most of the Australian exports go to New Zealand.

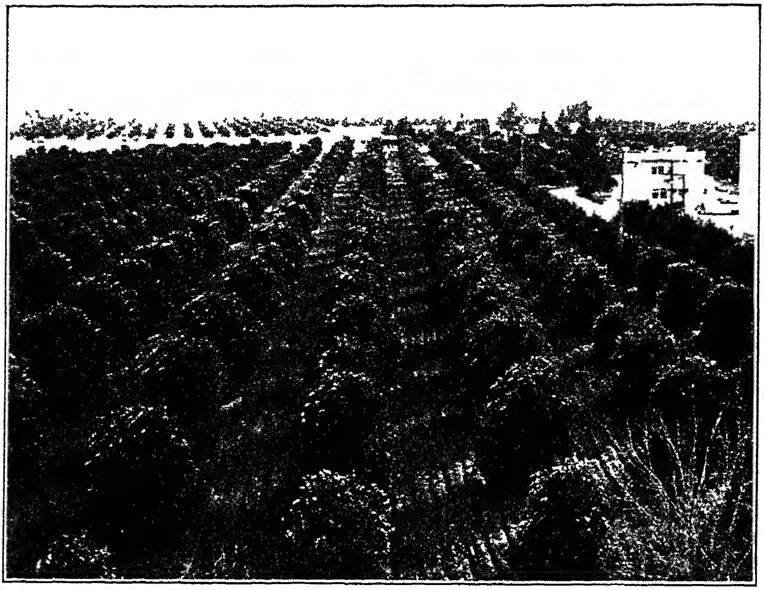
South America.—Except in Brazil, the production of oranges in South America is chiefly for home consumption. Brazil shows a definite trend toward substantial increase in both production and exports, a movement encouraged as a national policy in order to avoid complete dominance by coffee. Brazil's planted acreage is already about three-fourths as large as that of California, the potential crop of the near future may exceed 10,000,000 boxes Should this crop materialize, international trade will feel its effects quite distinctly, because Brazil produces the navel—a so-called winter orange of the same kind as the California product—and markets it during our summer. The Valencias of Spain and the United States will then have to meet the competition of the navels of Brazil in the great import centers of the Northern Hemisphere.

Japan and China—China, the probable home of the orange, is an important producer, but complete data as to quantities are not obtainable. Most of the oranges are consumed locally and therefore do not enter into the channels of foreign trade

In orange production Japan ranks fourth among the countries. In recent years the crop has averaged higher than 11,-

000,000 boxes Japanese oranges, popularly known as *mandarins,* are mostly of a different species than those grown in Spain and California, about 70 per cent being of this kind. The markets are chiefly domestic; the largest foreign markets include the nearby provinces of China and Manchukuo, although considerable quantities are shipped to Canada and the United States.

Of course neither Japan nor China has the dry subtropical type of climate. Oranges are grown without irrigation in the



Courtesy, Chamber of Commerce, Los Angeles

Fig. 218.—Orange groves, Los Angeles County, California. Commercial sorting and packing establishment at right.

southern parts of those countries where the humid subtropical climate prevails.

The United States.—The United States has become the world's largest orange producing country, and the trend here as in most other orange producing centers is definitely upward. There are two principal areas, both large and capable of greatly increased output—namely, California and Florida—while lesser quantities are produced in Arizona, Texas, and Louisiana.

Wherever oranges are grown, subtropical temperatures are found, but the rainfall varies from humid Florida and Louisiana to semi-arid California.

Florida was the earliest region of large production. For a time, following the Civil War, northern Florida found orange production highly profitable, and therefore extensive plantings were made. After several setbacks by cold waves which caused moderate losses, came the disastrous freezes of the winter of 1894-95, during which even the trees were killed. These disasters led to a shift in the commercial orange culture to the southern half of the state, where losses by freezing are not so likely to occur. Since 1920 great expansion has taken place, and Florida has again reached a high place in the winter orange trade.

The orange groves of California are subject to greater winter cold than are those of Florida, but the damage is not so great because the temperatures are steadier and are not interspersed with warm spells which bring the trees into active growth. To overcome or ameliorate the danger of frost, nearly all orchards are equipped with oil burning smudge stoves whereby the air temperature can be raised several degrees. Inasmuch as summers are dry and only moderate rainfall occurs in the winter season, irrigation is of course necessary to provide the needed moisture. The great markets of the United States have been incentives for the development of extensive and highly efficient irrigation systems. The mountains rising back of the coast have furnished the necessary catchment areas, but even so the water-supply is not sufficient to furnish irrigation waters for all the available land.

California has long been noted for its production of navel oranges for the winter markets. Economic success was achieved because of the favor with which these large, richly colored, seedless oranges were received in the markets. During the past decade or two, however, the California navels have been encountering increasingly keen competition from the seed-containing but juicy and well-flavored Florida product. Lower prices have ruled, and as a result growers have begun to favor

the Valencia oranges, which are juicy, of splendid flavor, and which contain few seeds. The increasing demand for orange juice and orangeade, especially in warm months, has been an important factor in bringing about this new trend in the industry.

A third center of orange culture is developing along the Gulf

Courtesy, Los Angeles Chamber of Commerce

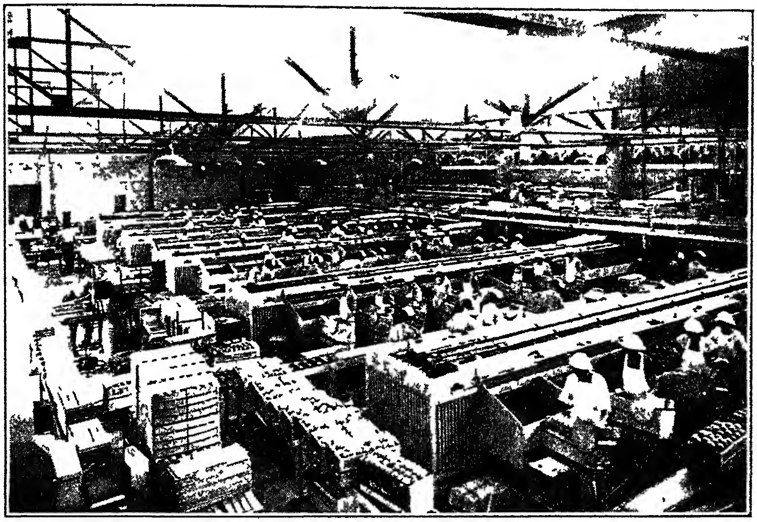
Fig. 219.—Picking oranges in southern California. The pickers wear gloves and handle the fruit with great care.

Coast of Texas Planting is actively going on, and the near future indicates marked increase in output But Texas, like Florida, must take into account the danger of freezing when the unwelcome northers sweep down to the Gulf from the cold interior.

The upward trend in the United States is clearly marked by the increase in average annual production from 21,400,000

boxes, 1915-1919, to an annual average of 38,480,000 boxes in 1925-1929, an increase of nearly 80 per cent in a decade. The commercial crop of 1930 reached the astounding figure of 54,-694,000 boxes of 70 pounds each. Although the years immediately following showed some recession from this high figure, the total crop held above 48,000,000 boxes.

Until recent years the United States exports were confined largely to the Canadian market. The larger crops of later years have led to a search for new markets, with the result that siz-



Courtesy, Los Angeles Chamber of Commerce.

FIG. 220.—Citrus packing plant, southern California. The fruit is graded as to size and quality and is carefully wrapped and boxed for the market.

able quantities have been shipped to Europe, notably to the United Kingdom. These have been mostly the Valencias for the summer market, since the navels encounter insurmountable competition with the large supply of low priced oranges from Spain, Italy, and Palestine. The American export trade in oranges is destined to encounter increasing competition with the expanding output of the Mediterranean countries in winter and of South Africa and Brazil in summer.

Viewed as a whole the role of the orange industry in the countries with dry subtropical climates is impressive. This is a tri-

bute to irrigation and to marketing methods There seems no danger of any world shortage in oranges in spite of greatly increasing demands The per capita annual consumption in the United States increased from less than 7 pounds in 1900 to more than 28 pounds in 1930 As a rule the per capita consumption in the United Kingdom slightly exceeds our own. These figures indicate the high favor in which oranges are held as fruit and food Fortunately, an ample supply to meet future demands is assured by the increasing output of the several producing regions of the world.

In conclusion.—Earlier in this chapter we called the attention to the claim made by some that the dry subtropical climate is a climate of achievement. The claim seems well founded The Mediterranean lands hold the proud position of being the homes of some of the greatest cultural heights ever attained by man. There were the centers of the Hebrew, Egyptian, Greek, and Roman civilizations In the modern world, regions of this type of climate boast not only of the present Mediterranean powers, but also of progressive centers in Australia, South Africa, central Chile, and southern California. These regions present a diversity of activities and products not excelled anywhere. Their winters attract visitors by the thousands, who come there to enjoy the mild temperatures and invigorating sunshine. Their surplus of fruits and vegetables are important additions to the world's food supply All in all, the world of today owes much as heritage from the past and as achievement of the present to lands having dry subtropical climates.

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CHAPTER XX

The Regions of Humid Subtropical Climate and Their Major Economic Products

WITHIN the transition belts which lie between the low and the middle latitudes, the rainfall conditions of the east coasts of the continents are strikingly different from those of the west coasts. East coast regions have annual rainfall generally in excess of 40 inches, thus producing distinctly humid conditions. Since growing seasons are from 10 to 11 months long, and frosts may occur only during a short period each year, the climate is known as the *humid subtropical* type It is sometimes called the cotton belt climate because of the importance of cotton culture in some of the regions There is much variation in monthly distribution of rainfall; in the southeastern United States, for example, there is rather even distribution throughout the year, whereas in southern China the winters are relatively dry. The warm period within the humid subtropical regions is, however, a rainy season everywhere, which is of course in sharp contrast to the dry subtropical type, where winters are rainy and summers dry

THE HUMID SUBTROPICAL TYPE OF CLIMATE

In all regions having humid subtropical climate, frosts are rare along the equatorward margins; in the higher latitude portions, freezing temperatures may occur during several months. This is particularly true where this type of climate prevails over extensive areas, as in the United States and China.

Temperature.—A characteristic common to nearly all places within the humid subtropical regions is the possibility of the occurrence of frosts during one to four months each year In the warmer latitudes there is a probability of frost only dur-

warmer, the humidity is higher, and because they last so much longer than those farther north In other words, the "sensible" temperatures, that is, the way the heat affects our physical and mental faculties, are relatively high

The winter seasons are mild, and much vegetation remains green throughout the coldest months Snowfall is rare in the warmer latitudes and occurs only in the severest weather in the cooler areas In the United States the most distressing features of winter are the cold waves which this region occasionally experiences. At times the cold of the interior is carried all the way to the Gulf Coast and eastward to the Atlantic causing severe damage to vegetation and physical discomfort to man. In China, also, winter temperatures become rather severe where areas are exposed to the sweep of cold winds from the interior, whereas places near the coast and those protected by mountain chains have mild winters On the whole, while the seasonal fluctuations of temperature do not swing to great extremes, there are sudden changes of considerable intensity which serve to stimulate mental as well as physical activity.

In the humid subtropical regions of the Southern Hemisphere the temperature shifts are much less pronounced. This is due to the dominance of oceanic influence and the lack of any extensive adjacent land masses poleward Winter seasons are not so cool as in the Northern Hemisphere, and temperatures are much steadier

Winds.—The winds are generally light and variable. In the high-sun period known as summer, the winds of trade wind character are dominant, but they are marginal and lack the vigor which characterizes them in lower latitudes. This is particularly true in China and the United States because of the monsoonal conditions brought about by the large land masses of Eurasia and North America As winter approaches, the trades retreat; the westerlies follow and encompass these regions, becoming dominant in the cooler belt, but only partially so in the warmer. In the United States the low pressure areas of the westerlies dominate the northern part of the region, but even during the winter season they are only partially effective

in the southern part. In China the in-blowing monsoon dominates the summer, while cold, out-blowing monsoon winds rule the winter. On that account the climate of southern China is less true to type than it is elsewhere, the winters being rather dry and considerably colder than one would expect judging by

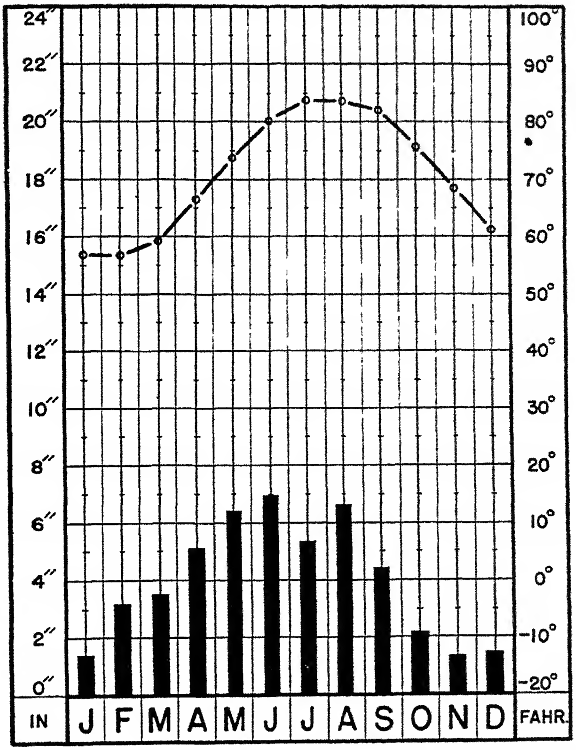


FIG. 222.—Humid sub-tropical climate (monsoon variant) Average temperature and precipitation for Amoy, southern China. Altitude 12 feet, total precipitation 47 inches.

latitude, whereas in the other regions the winters are short, mild, and rainy.

During the latter part of summer, tropical hurricanes occasionally reach the coasts, causing serious damage to crops and shipping. Although usually less vigorous than in tropical latitudes, they constitute a menace to orcharding and city building that should be reckoned with along the Gulf Coast of

the United States and in southern China and Tonkin. Since these late summer storms are most likely to occur when crops are approaching the harvesting stage, the losses resulting from their invasions often reach high figures Damages to orchard crops are especially serious, because often the trees as well as the fruit are destroyed.

Rainfall.—The rainfall is heavy, the annual average ranging from about 35 to over 60 inches On the whole the average in regions of humid subtropical climates is more than double that of the dry subtropical regions. Furthermore, the rainfall is somewhat more evenly distributed throughout the year; this is markedly true in southeastern United States in contrast with the highly seasonal distribution of rainfall in California. In the southeast there is no prolonged dry period, but since the autumn usually receives less rain than the other seasons it is often called dry Most of the precipitation occurs as rain, although some snow falls every winter in the northern sections Along the southern margin snow is rare, in some places unknown

In the United States the summer rains are mostly of the thunderstorm type, heavy and of short duration These are due to the convectional currents set up by contact of the air with the summer-heated land As the air is forced to rise, it is chilled by expansion and by mixing with the colder air of higher levels, and a large part of the water vapor of the ascending currents is suddenly condensed into droplets Thus are formed the well-known, often strikingly-shaped, cumulus clouds popularly called thunder heads The resultant rains vary locally from showers to so-called cloudbursts, they do not last long and usually occur late in the day or early in the evening Summer sunshine is thus relatively abundant In winter, on the other hand, the rains are more prolonged, often lasting from 12 to 48 hours; the skies are wholly overcast with clouds mostly of the stratus, blanket-like type, and the rainfall is less intense, varying from a drizzle to a steady downpour. These rains are due to the cooling of the warm, moist air from the Gulf of Mexico and the neighboring Atlantic by the colder air from farther

north The great whirls of the cyclonic storms which pass over this area in winter cause the cold air to flow under the warm air, inducing the latter to rise. Adiabatic cooling below the dewpoint causes cloud formation, and the rains which result usually cover large areas The high relative humidity which prevails in winter causes even the mild temperatures of that season sometimes to feel raw and disagreeably cold Since the houses, as a rule, are not built to withstand cold and are not provided with heating systems, the winter season is one wherein poorly clad people shiver and shake and hope for spring

Conditions in the other humid subtropical regions of the world bear a general resemblance to those in southeastern United States, but they differ greatly in some phases Southern China, for example, has much more distinctly seasonal variation in rainfall. The southerly winds of the summer monsoon give rise to high temperatures and much rainfall: the northerly winds of the winter monsoon are cold and dry. Thus heavy rains characterize the summer months, while during the winter months rainfall is low

The humid subtropical region of South America extends northward to the truly tropical conditions in Brazil and Paraguay and southwestward to the semi-arid plains which lie at the foot of the Andes Within this extensive region the rainfall conditions vary widely. Precipitation is well distributed and generally dependable in the heart of the Plate River area, but toward the margins of the region, especially on the westward front, it is lower and less dependable. Severe droughts, which often result in heavy losses in grain and forage crops, are not infrequent there.

Native vegetation.—Under prevailing conditions of abundant rainfall and moderate temperatures it is to be expected that forests should be the predominant phase of the native flora Savannas, or grassy plains, are usually limited to areas such as occur in some of the low-lying islands and on the tidal flats of the Carolinas, where the ground is so water-soaked that trees will not thrive. The Argentine Pampa is, however, a conspicuous exception to the prevalence of forest on humid, well-

drained lands The tall grass prairie appears to have been the native vegetation, but scientists are not agreed upon the causes responsible for it

Three broad groups of trees are dominant; namely, the broad-leaved evergreen, the broad-leaved deciduous, and the narrow-leaved evergreen Where winters are mildest, the broad-leaved evergreens are most numerous, magnolia and live oak being among the best known. Thus, along the warm margins of these climatic areas, as in Florida and along the humid Gulf Coast of

Photo by U S Forest Service

Fig 223.—Evergreen magnolia tree near Gulfport, Mississippi Exceptionally large, has 80-foot spread

southeastern United States, in southern China, in northern Uruguay, and in southern Brazil, the broad-leaved evergreen trees predominate on the lands where the soils are richest. Along the poleward margins the winters are so much colder and longer that seasonal leaf fall is induced, and hence there the broad-leaved deciduous forest is dominant on the richer lands, oaks and poplars being the most common representatives.

The narrow-leaved forest, chiefly coniferous, is found on the higher lands and on lowlands where the soil is relatively poor. Thus, extensive pine forests characterize the sandier portions

of the Cotton Belt of the United States and the hilly lands of parts of southern Brazil. Southeastern United States has for years been the principal source of supply for yellow pine lumber for domestic markets. The industry, however, has carried on logging operations so ruthlessly and without any attempt at reforestation that at present the timber supply of the South is seriously depleted. In general, the cut-over pine lands are not

Photo by U S Forest Service

Fig. 224.—Virgin stand of long leaf pine. Choctawhatchee National Forest, Florida.

productive crop lands; large areas are suitable only for forest and should be so utilized.

The natural conditions may favor the growth of conifers in humid subtropical lands in any one of three ways: (1) the soil may be so sandy that broad-leaved vegetation will not thrive, as in the Sandhills of the Carolinas or on the sandy lands of parts of Florida and Georgia; (2) the clay lands may be so leached by heavy rainfall that their productivity is low, as is the case with some of the rolling uplands from Louisiana to

Virginia; or (3) the altitude may be such that greater and more prolonged winter cold locally displaces the true subtropical climate with more northerly temperatures, as in the mountain areas of the southern Appalachians With few exceptions the pine lands of warm, rainy subtropical climates are too lean for crop production, and the lands where broad-leaved vegetation abounds are the ones best adapted for agriculture

Soils.—Inasmuch as the regions of subtropical climates are transitional between the all-year warm of lower latitudes and the seasonal warm and cold of the middle latitudes, and since they are often bordered by the drier climatic regions of the interior, it is not surprising that the soils should likewise show transitional characteristics. The influence of the prevalently higher temperatures in the equatorward areas is reflected in the distinctly reddish soils, while in the poleward areas of these regions the soils generally have a yellowish color. In the warmest, most humid areas, lateritic soils are not uncommon In general, the mature upland soils are of the groups known as the red-and-yellowerths, fairly heavy clay soils, having the color characteristics indicated by their names.

Because of the high rainfall, the soils are so fully leached that they are weak in lime and other soluble mineral salts, and therefore belong to the general group of the pedalfers Structurally they vary from fairly stable, similar to those of soils in cooler climates, to weak, such as are commonly found in the tropics Inasmuch as soils having weak or poor structure entail heavy costs in labor and fertilizers if productivity is to be maintained, wise selection of lands is necessary for successful agriculture.

The alluvial lands are in general the most productive In southern China agriculture is practically limited to the flood plains along the numerous streams; among these the Yangtze plain and the deltas of both the Yangtze and the Si Kiang are the largest and the most densely populated In Argentina the broad plains of the Plate River area have young soils of high fertility, to which much credit must be given for the successful agricultural development of that region.

In southeastern United States the upland soils are relatively

poor and require continued application of large amounts of fertilizer and labor for profitable production This is a decided handicap when the crops must be sold in competition with those of soils upon which such costs are lower Wolfanger has aptly presented the relationship of soils to specialized agriculture in the American Cotton Belt[1] From a climatic point of view, corn can be raised successfully; good yields are obtainable, but nevertheless corn is insignificant as a commercial crop because farther north in the United States it does well with little or no expense for fertilizer. Cotton, like corn, can be grown only with the use of heavy applications of fertilizers, but unlike corn the crop does not have to compete in the market with one raised without such expense

Agricultural industries.—The humid subtropical regions are capable of producing a wide variety of crops; the growing seasons are long, the winters are short and mild, and the rainfall is sufficient In such a favorable natural environment the number of plant species which can thrive is large, and therefore the choice of crops to be raised depends more directly upon the competition of similar products raised elsewhere than is the case in some other regions For example, in southeastern United States cotton is king, whereas under similar conditions in the Plate River region, corn wears the regal crown In southern China, cotton is important, but corn is displaced by rice Although little cotton is grown in the humid subtropical regions of South Africa and Australia, it is of such great importance in America and China that the term "cotton belt climate" is fully justified to designate the type

Since the humid subtropical climate is within the transition belts between the tropical and the middle latitudes, wide variation in the agricultural products of the warm and the cool marginal areas is inevitable. This holds true especially in southern China, in the Plate River region, and in southeastern United States. In these regions the warm margins raise subtropical products—such as citrus fruits, sugar cane, and early vegeta-

[1] Wolfanger, L A *Major Soil Divisions of the United States*, John Wiley & Sons, New York, 1930, pp 108-110

bles—while the colder margins merge into the temperate cereal areas—particularly those which produce oats, corn, and wheat.

In the United States the agriculture of the humid subtropical region rests broadly upon a three-fold basis Cotton is the dominant crop in the extensive middle zone, flanked on the south by a belt in which the growing of citrus fruits, early vegetables, and berries predominate, while on the north it is bordered by a belt of mixed farming· cotton, oats, corn, wheat, and tobacco Throughout the region corn is grown for local use as feed for animals and as food for man The Cotton Belt is the land where corn pone and johnny cake are in favor to a far greater degree than in the states to the north where corn is king.

Live stock.—Although the humid subtropical climate is, in general, a friendly one to animals as well as to plants, it is not particularly favorable for livestock production. Feed is plentiful, but the native grasses lack the high nourishing qualities which are characteristic of the grasses in cooler climates Insects are so numerous, especially ticks, that they are a serious handicap to the development of a dairy industry The ravages of ticks can be controlled by dipping the cattle at frequent intervals, but since the effectiveness of this method of control depends on its usage by all, organized enforcement is necessary—and that adds to the expense of production Hence, while cattle ranching is carried on extensively in some places where land values are low and where grass is plentiful, the humid subtropical areas as a whole are of little importance in the dairy industry because they cannot compete successfully with regions of cooler climates, more nutritious grasses, and fewer insect pests.

Since horses do not thrive well in regions where summers are long, warm, and humid, the most commonly used draft animals are mules, because they are much more tolerant of these conditions The mule has long been the mainstay of cotton production. Working either singly or in a two-mule team, his presence is as essential to the American cotton landscape as is the colored boy or the old Negro mammy. Hogs abound, usually lean and fleet of foot, quite in contrast to their rotund cousins of Iowa.

Poultry are kept as adjuncts to the farm because they convert into palatable foods what would otherwise be wasted Negroes, preachers, and chickens have so long furnished the basis for the colorful tales of the Southland that without them the picture of that region would not be complete

In the Plate River region the livestock industries hold a much more important place than they do in southeastern United States There, for a long time, cattle ranching was the principal industry. With increase of population, ranching has been displaced in large measure by grain farming, but cattle ranching is still a major phase of agriculture and, in recent years, hog raising has greatly increased

SUBTROPICAL FRUITS AND EARLY VEGETABLES

In all the regions of humid subtropical climate the production of fruits and vegetables is important for local sustenance. Commercial production, however, has reached a greater development in southeastern United States than anywhere else, because the population centers farther north afford splendid markets easily reached by modern transportation facilities On the coastal lands from Texas to Virginia, vegetable gardening of all sorts is the leading form of commercial agriculture. The profits depend largely upon the possibility of marketing the products before they must meet the competition of those grown near the population centers Growers must, therefore, plant as early in the season as possible, and risk the danger of frost Potatoes from Florida and southern Texas run a close race with those from Bermuda in reaching northern winter markets Louisiana is the leading state in furnishing early strawberries, sending them out by the carload in March and early April. Southern Mississippi has developed a huge production of early tomatoes.

In central and southern Florida citrus fruits occupy the center of the stage There the severity of the winter cold waves is so modified by the warm ocean water on both sides of the peninsula and by the numerous lakes which dot the surface that large-scale production of the tender subtropical fruits is pos-

sible. Florida vies with California as an orange growing state Favored by abundance of rainfall, extensive areas of relatively cheap land, and by proximity to markets, the outlook seems to favor continued expansion in this line

Grapefruit production.—The peninsula of Florida is the world's foremost center of grapefruit production; during the period 1925-1930 it produced about 90 per cent of the world's supply. The percentage will probably show a decline during the present decade because of greatly expanded plantings in southern Texas, Arizona, and California. One of the remark-

Courtesy, Florida Citrus Fruit Exchange, Tampa, Florida.

Fig. 225.—Grapefruit orchard in full bearing, near Tampa, Florida.

able developments in recent years has been the tremendous increase in production and consumption of grapefruit in the United States In 1925-26 the total world output was approximately 9,300,000 boxes of 70 pounds each; in 1929-30 it had reached over 12,100,000 boxes, of which the United States and Puerto Rico produced over 96 per cent Plantings already made indicate that the United States alone may produce more than 20,000,000 boxes before 1940 Expansion of grapefruit culture is reported in the West Indies, in Palestine, and in South Africa, so it is evident that continued increase in consumption is essential or the market will be depressed below the point of

economic returns to the grower Florida and Texas will probably remain the principal centers of production because of abundance of suitable land, sufficient rainfall, and less danger of loss by hurricane than in the West Indies.

Peanuts.—The peanut, thought of by most people as something to be sold in small paper bags and eaten at circuses and ball games, is a product of increasing commercial importance as an animal feed and as a source of vegetable oil Peanuts thrive best in sandy soils and where warm temperatures and moderate rainfall prevail throughout a long growing season. Commercial production becomes profitable where labor is available at relatively low cost and where local markets are important because of dense population, or where distant markets are available through cheap transportation facilities.

Peanuts are produced in tropical and subtropical lands, and important centers of production have developed in southern Asia, southeastern United States, and in western Africa The principal exporting countries are British India, Senegal, China, Nigeria, and Gambia. In British India production is favored not only by a dense population that uses peanuts as one of several sources of edible oils, but also by the favorable export markets of Europe. These influences have led to marked increase in plantings in recent years. Peanut growing has been fostered in western Africa by the French and British, whose colonial possessions are considered natural sources of supply of edible vegetable oils needed by the home countries In China, peanuts have in recent years become a major cash crop in the Shantung area and adjacent portions of the country, with an annual crop estimated at about 600,000 tons, of which about one-third is exported

In southeastern United States peanuts are important in every state from Texas to Virginia. The acreage has quadrupled since 1899, one of the most marked increases shown by any crop. Recent figures have placed the total area in peanuts in the United States at nearly 2,500,000 acres with production exceeding 750,000 tons.

COTTON

Although the agricultural activities in humid subtropical regions are characterized by considerable diversity, cotton is the outstanding cash crop It may be secondary to cereals as in the Plate River area or in South Africa, or it may be eclipsed by rice and tea and silkworms as in southern China, but nevertheless, even there its culture leads to substantial production. It is quite true that much cotton is grown where the climatic conditions are more tropical than subtropical, as in India, or where they are more dry than humid, as in Peru, Arizona and Egypt. The world's greatest area for the commercial production of cotton, however, lies in southeastern United States, a region of humid subtropical climate

Climatic requirements.—Cotton is grown in the United States only where the frostless season is more than 200 days long and where the average summer temperature does not fall below 77°F. During the period of vegetative growth sunshine must be abundant, and the nights as well as the days must be warm. As a result of these rather exacting temperature requirements, the cultivation of cotton in America, as well as in other parts of the world, is limited to regions with a subtropical or a tropical climate.

The cotton plant needs a moderate amount of moisture, well distributed throughout the growing period. An annual rainfall of 30 to 50 inches, or its equivalent in irrigation water, is considered most favorable During the harvesting season, however, comparatively dry weather is essential, because the quality of the cotton fiber in the open boll is impaired by rain and high humidity Since the rainy equatorial belt of the tropics lacks a pronounced dry season, cotton cannot be cultivated successfully there. Thus, cotton growing on a commercial scale is carried on generally in regions with either a humid subtropical or a tropical savanna type of climate. Most regions with a mediterranean type of climate are handicapped by insufficient rainfall.

Historical significance.—Cotton was used for the manufacture of coarse cloth by the Indians of northern South America,

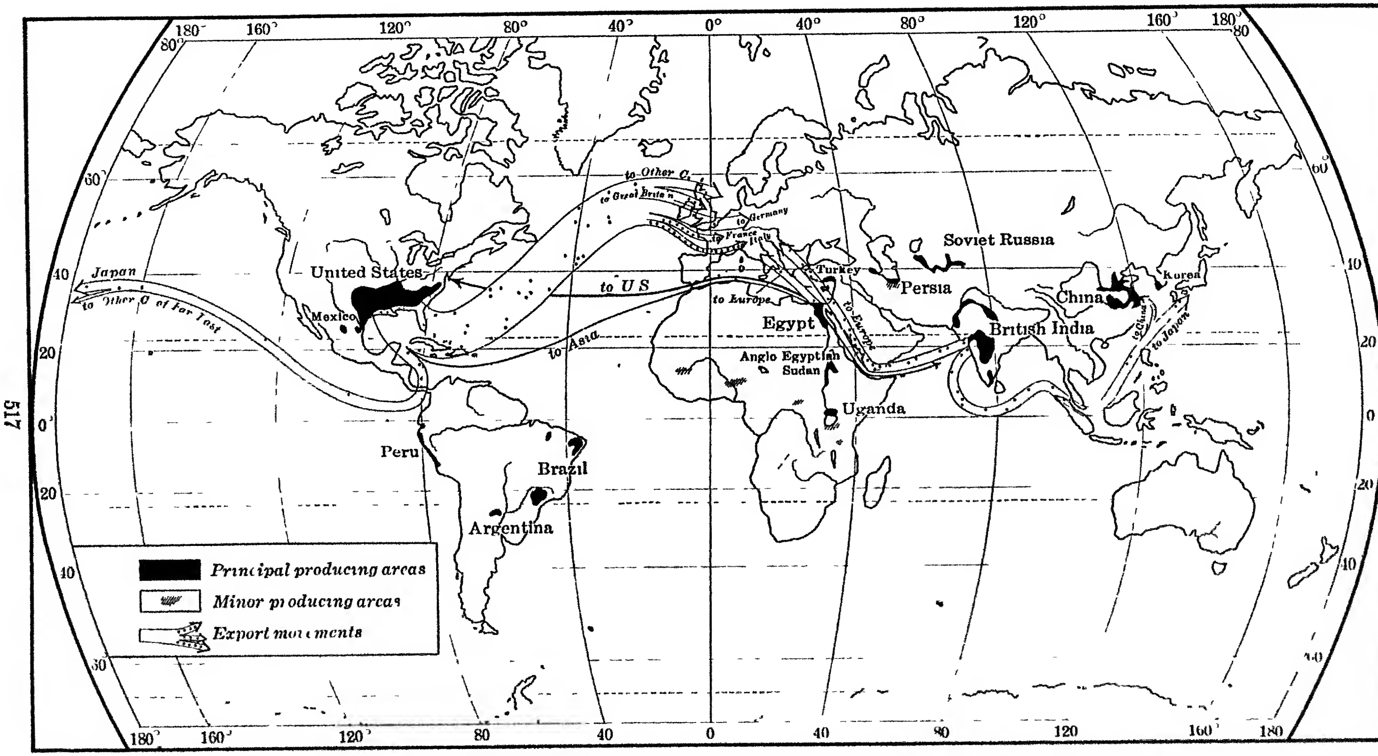


Fig. 226.—Principal cotton producing regions of the world and trade in cotton.

Central America, and the West Indies before the arrival of white men Long before the dawn of history it was a cultivated plant in the Indus Valley and neighboring regions, reaching Egypt as early as the fifth century B. C It was not until the end of the eighteenth century, however, that the cotton fiber was first used by the textile industries of western Europe. At that time most of the raw cotton came from the Near East, although small quantities were imported from the West Indies and the Guianas The fiber was separated by hand or by primitive machinery from the seeds to which it was attached, a slow, laborious, and costly method which made it too expensive for general use in making wearing apparel The invention of the saw gin by Eli Whitney in 1793 made possible the mechanical separation of fiber and seed on a large scale The modern cotton gin and the power-driven spinning and weaving machinery have so reduced costs that cotton has become not only the cheapest but also the most universally used fiber manufactured into clothing and household textiles

The spectacular growth of the cotton industry in England and in New England opened the first chapter of the industrial revolution so often referred to by historians and economists. Cheap cotton cloth began to replace linens and woolens in nearly all parts of the civilized world, and thus was created an immense and rapidly expanding market for machine-made cotton goods In response to this increasing demand, cotton acreage rapidly expanded, especially in the United States. Cotton began its rule in the South which, for better or worse, has lasted until the present.

Principal cotton regions.—The harvesting of cotton is still largely done by hand labor The cotton is picked from the shrub, a competent picker being able to gather about 150 pounds in the course of a day Harvesting machinery has generally proven wasteful and impractical, primarily because the bolls do not all open at the same time. Cotton, therefore, requires not only favorable climatic conditions, but also much cheap labor Only certain sections of the subtropical and tropical savanna regions can meet both of these requirements. Com-

mercial cotton production at present is limited to a rather small number of well defined regions, among which the most important are the southern part of the United States, British India, central China, Egypt, and Russian Turkestan Of secondary importance are Brazil, Mexico, Peru, Uganda the Anglo-Egyptian Sudan, Korea, and Turkey The United States alone produces more cotton than all the other regions combined

Types of cotton.—From a commercial point of view cotton is classified on the basis of the length of the fiber or the staple. Cotton with a fiber of less than 1⅛ inches is classified as short staple; that of which the fiber measures more than 1⅛ inches is called long staple By far the largest part of the cotton crop of the world belongs to the short staple class Since staple length determines the use to which the cotton can be put, the longer the staple, the finer the yarn that can be spun, and the finer the cloth that can be woven. The best Sea Island cotton, with a staple length of more than five inches, may yield as much as 150 miles of yarn per pound of fibre Short staple cottons make coarse yarns and therefore coarse cloth. Some cottons have such a short staple that they are hardly fit for use in the manufacture of textiles

Courtesy, New Orleans Association of Commerce

Fig. 227.—Cotton field showing opened bolls ready for picking.

Cotton in the United States.—The United States produces between 55 and 60 per cent of the world's cotton and consequently is the dominant influence in the world market. The Cotton Belt lies south of the 36th parallel and east of the 100th meridian No cotton is grown in most of Florida, and very little

within 50 or 60 miles of the Gulf Coast, on account of high rainfall and high humidity during the harvesting season. Cotton is grown on various types of soil, from sands to light clays, but the yields are largest on the black prairie soils of Alabama Mississippi, and Texas and on the bottomlands of the "Yazoo Delta" above Vicksburg. Since the annual rainfall is quite heavy, generally 35 inches or more, over all of the Cotton Belt east of Texas and Oklahoma, commercial fertilizers must be applied liberally to the leached soils in order to insure even moderate yields of fiber.

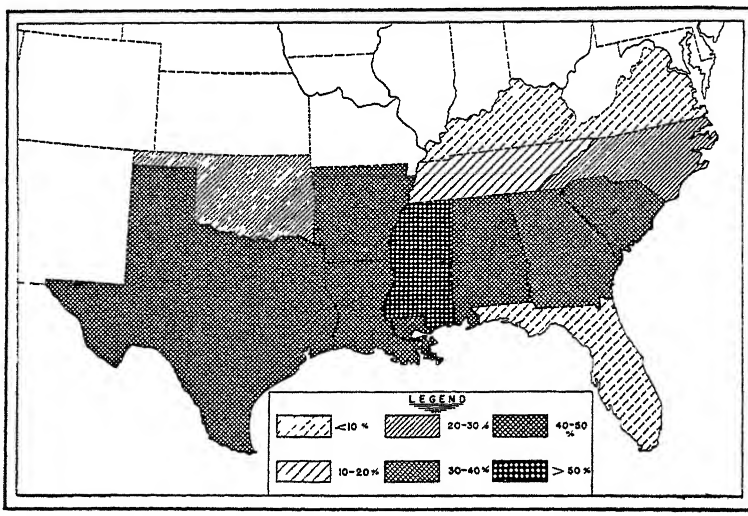


Fig. 228.—Percentage of tilled land in cotton in the southern states (Source *Fifteenth Census of the United States*, Bureau of the Census, Washington, D C, 1930)

The area in cotton has increased steadily from less than 10,000,000 acres in 1870 to more than 45,000,000 acres in 1930 This expansion has been accompanied by pronounced changes in the distribution of the cotton acreage. In South Carolina and in Georgia cotton has lost ground, while west of the Mississippi the area has expanded rapidly. Texas has become the leading producer, contributing nearly a third of the total crop. In most of Texas and Oklahoma yields of non-irrigated cotton are low, but the farms are larger than in the older parts of the

Cotton Belt, and since the bolls ripen at approximately the same time the cotton can be picked mechanically by means of the so-called "cotton sled" The dry climate of these states has proved to be a great advantage in limiting the depredations of the boll weevil, which flourishes in the more humid environment to the east An added advantage of the region west of the Mississippi Valley is that the soils are fertile and not subject to much leaching, and therefore less fertilizer is needed.

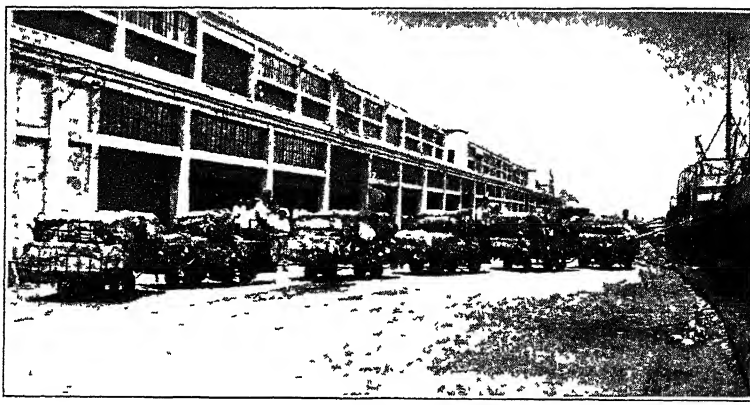
That the bulk of the crop in the American Cotton Belt is essentially of one type is another factor of economic significance The fiber of the upland short staple cotton, which constitutes more than 90 per cent of the total, is considerably longer than that of the Asiatic cottons, and therefore it is in great demand by cotton spinners all over the world Some long staple upland is produced with fibers of from 1⅛ to 1¾ inches. Production of this type of cotton is, however, limited to certain sections of the Cotton Belt, especially in the Pecos and Red River Valleys of Texas and on the Mississippi Delta

Cotton has put an indelible mark upon the entire economic and social life of the southern part of the United States. The plantation system and negro labor were largely responsible for the rapid spread of cotton cultivation during the first half of the last century The old system of slavery has been supplanted by a system of tenancy, from 60 to 70 per cent of the farms in the cotton states being operated by tenants, while white farmers produce considerably more than half of the crop Most of the cotton, especially in the old part of the cotton belt, is grown on small farms The necessity of picking by hand limits the acreage of cotton per farm, and few other crops can be grown because the labor peaks nearly coincide with those for cotton. The small size of the farms prevents the use of much farm machinery. Thus the South has become a region of small farms and of a monocultural system of agriculture, with all its attendant evils. For many years education and agricultural leaders have been urging more diversified farming, but their efforts have met with faint response More recently the Federal Government has entered actively into the program of plan-

ned production and through its influence the trend may shift somewhat, but even so we shall still expect cotton to be the crop which rules the realm

Ordinarily, about 40 per cent of the American cotton crop has been used in domestic manufactures and 60 per cent exported, principally to European countries and to Japan The principal cotton shipping ports are Galveston and New Orleans

Other cotton producing countries: *India*—Although cotton is widely grown in British India, the principal districts lie in the western part of the Deccan Plateau The climate is of the tropical savanna type, with precipitation of 20 to 50 inches and



Courtesy, Board of Commissioners of the Port of New Orleans

Fig. 229.—Bales of cotton being loaded into ocean-going steamer for export. Cotton Warehouse Wharf, New Orleans.

a dry period which lasts approximately from October to June. In the western part of the Deccan Plateau lava sheets, comparable to those of the Columbia Plateau of the United States, have given rise to fertile black soils which are retentive of moisture and are not in need of irrigation Cotton is also grown extensively on the ferruginous soils of the southern part of the plateau It is planted in the beginning of the wet monsoon and can be picked during the dry winter monsoon from October to March.

In the Punjab or Upper Indus plains, and in the Sind or Lower Indus Valley, irrigation is necessary for cotton culture The

Sukkur or Lloyd Dam, one of the largest irrigation projects in the world, provides water storage for irrigation of the Lower Indus Valley.

Although some American type cotton is grown in the irrigated districts, the bulk of the Indian cotton has such short staple, generally less than half an inch long, that it can be used only for coarse yarns and coarse types of cloth Part of the crop is consumed either locally or in the Bombay textile district, but more than half is exported. Japan is India's best customer for raw cotton, but considerable amounts are also exported to China and to European countries. Bombay and Karachi are the principal ports of shipment

Fig 230.—Principal cotton-producing countries of the world Average 1928-1929 to 1931-1932. (Source of data *International Year Book of Agricultural Statistics*, International Institute of Agriculture, Rome)

Egypt.—Egypt has a desert climate, and agriculture depends entirely upon the water provided by the Nile River. Cotton, famous for its long, silky fiber, occupies about one-third of the cultivated land and is grown principally on the low, fertile, and easily irrigated lands of the Nile Delta. It is in great demand in Europe and the United States by manufacturers of fine yarns, fine textiles, and automobile tires.

China.—The principal centers of cotton production in China are the hinterland of Shanghai—i.e., the middle and lower valley of the Yangtze River—and from there northward into the fertile delta lands of the Hwang-ho Although the production is so large that China ranks as one of the principal cotton

countries of the world, but little is available for export. Domestic demands absorb practically the entire crop

Russia.—In Russia cotton is grown extensively under irrigation on the fertile loess soils of Turkestan The area has increased from less than 2,000,000 acres in 1910 to more than 5,000,000 acres in 1931. Further expansion is probable but ultimately will be limited by lack of available water. Most of the cotton is of the American upland type

South America—In South America the principal producing centers are Brazil, Peru, and Argentina. Brazil has been of little importance as an exporter, the total crop having been relatively small, but since climatic conditions over large areas of eastern Brazil are favorable for the production of cotton, a definite upward trend may be expected According to Pearse, it is not impossible that the area suitable for cotton growing in Brazil exceeds that now so used in the United States[2] In Peru cotton is grown in many of the irrigated valleys of the coastal desert The Peruvian product has a long staple and is in demand by American manufacturers of automobile tires

Production.—Since the World War several countries, especially the United Kingdom and France, have been endeavoring to make themselves more independent of American cotton. In the African colonies of these two countries governmental encouragement is causing a slow but steady expansion of the acreage In the Anglo-Egyptian Sudan the Gezira irrigation project, on the Blue Nile near Khartoum, has made possible the development of a new region, which produces mostly long staple Egyptian cotton In Uganda, American upland cotton has become an important crop

All regions outside of the United States have shown a decided upward trend during the last twenty years. Nevertheless, there is little likelihood that this country will lose its role as the leading producer, since nowhere else in the world is such a large area available where cotton can be grown without the expense incidental to irrigation Continued supremacy depends, how-

[2] Pearse, A S *Brazilian Cotton,* International Federation of Master Cotton Spinners, Manchester, 1922

ever, not only on the favorable natural environment but also on cheap labor whereby the crop may be produced and sold at prices low enough to hold foreign markets in the face of increasing competition with other countries.

Raw cotton is light, can be tightly compressed into bales, and does not spoil easily Since it can be shipped long distances at low cost, areas of manufacture need not coincide with areas of production but can seek locations where power and cheap labor are available As a result of these various factors cotton has become an important article in world trade.

Centers of consumption of raw cotton.—The principal cotton textile districts of the world are located in Great Britain, the United States, Germany, France, Italy, Czechoslovakia, and other European countries. Important cotton manufacturing districts have developed in recent times in Japan (Osaka, Nagoya, and Tokyo districts), in British India (Bombay district), and in China (Shanghai district).

The cotton industry of Great Britain is concentrated in the Lancashire district, Manchester being the principal center. Before artificial means had been devised whereby a desirable degree of humidity could be maintained in the factories, the damp climate of Lancashire, caused by its location on the west side of the Pennine Mountains, was of great advantage for cotton manufacturing This advantage persists and is still of some economic value Furthermore, coal for power is available within the district, and the factories are within easy reach of the sea for the importation of raw material and the export of the finished products Because of the importance of Lancashire, Liverpool has long been the greatest cotton importing and trading center of the world In recent years the district has suffered somewhat from the competition of new textile centers, especially those in the Far East and in British India.

The American cotton textile industry started in New England, where cheap waterpower and a good labor supply were both available For long years that section held undisputed supremacy in cotton manufactures. During the last two decades, however, the trend in the South has been definitely up-

ward, particularly in the Piedmont districts from North Carolina to Alabama, where cheap labor, proximity to the raw material, and a plentiful supply of water power have been factors favorable to industrial expansion As a result, the South has far outstripped the North in the manufacture of cotton goods. In 1930 the New England states consumed approximately 700,000,000 pounds of raw cotton, while the four southern states mentioned above consumed more than 2,300,000,000 pounds. The old agricultural South has become changed into a section where manufacturing interests will compete definitely for labor and for public favor with agriculture That this change will be profound, not only industrially but also socially and politically, appears inevitable.

RICE

Where, in the dim past of early human progress, rice originated is unknown Wild species of rice are found in the wet swampy regions of southeastern Asia as well as of tropical Africa. The principal species that was domesticated, *Oryza sativa,* has retained all the characteristics that indicate an original swamp habitat There are numerous varieties of rice, each with its own particular characteristics and requirements, but all must have high temperatures in order to germinate, bloom, and mature Some of the tropical varieties will not germinate at temperatures below 68°F., and the most favorable temperature is often considerably higher

These temperature requirements make rice a crop of the tropics and subtropics Whether more rice is grown in the former than in the latter is difficult to say because of inadequate statistics and the lack of a sharply defined line between the two types of climate. Within this larger area, however, the geographic distribution of the rice crop is limited by its heavy needs for water It must have much water, not only in the soil but upon it. The easiest way to comply with this requirement is to irrigate and temporarily flood the land The germination of rice, unlike that of most other crops, is unhampered by lack of air, and it finds a swamp habitat more favorable for growth

Methods of production.—With an unlimited expense of labor, lasting for generations, the land has been terraced and subdivided into small holdings. Each parcel is surrounded by a little dike to hold the irrigation water, which is admitted or pumped in at the upper side of the terrace system and led slowly from terrace to terrace until the surplus again reaches the river below The individual rice fields, "paddies," or "sawahs," or whatever their local names may be, are prepared most meticulously. They are ploughed into a thick, soft mud and carefully levelled The primitive economy of the native farmer and the small sizes of the fields preclude the use of modern machinery. About the only kind of animal that can stand the rigors of labor and climate is the slow, rather undisciplined carabao, or water buffalo The young plants, grown with utmost care and attention in nursery beds, are transplanted into the muddy field by hand Cultivation and, later on, the harvesting are likewise carried on almost entirely by hand labor.

Social relationships.—Rice cultivation—with the attention given individual plants and with the everlasting care for the maintenance of terraces, dikes, and irrigation works—is one of the most labor-intensive types of agriculture in existence; in many places it borders on true horticulture Where the conditions of the natural environment are favorable, especially where an ample supply of water is assured rice is one of the safest crops that can be grown With sufficient water, crop failure is rare, although in some lowlands there always lurks the danger of destructive floods The cultivation of rice thus both depends upon and makes possible a dense population The areas of great rice production are for the most part also areas where the density of population is far above the average

Rice production is necessarily a stable industry, greatly dependent upon orderly, peaceful conditions, and therefore is apt to develop a highly conservative small peasantry, strongly rooted in the soil. The cooperation and organization that are essential elements in successful rice cultivation have undoubtedly done much toward the early development of such civilizations as those of India and China

No dietary habit seems to be more strongly entrenched than the eating of rice, and no agricultural habit seems to have become more strongly entrenched than the growing of rice The Hindu peasant of the lowlands, the peasant of Java, or of southern China tends to grow rice wherever he goes. This tendency may explain the cultivation of rice in areas which are seemingly on the extreme margin of profitable cultivation as in northern Hondo and southern Yezo, in north China and in Manchuria This preference for rice coupled with the pressure of population and the absence of adequate transportation facilities may explain the staggering amount of manual labor expended in the regions upon the terracing of hillsides—and even of mountain flanks—in order to make them fit for irrigation and thus for rice

Western agriculture, which has always centered around the bread grains, has given relatively little attention to rice. In Europe only a few areas, the plains of Valencia in Spain and of the Po in Italy, are climatically fit for the growing of this cereal. With the aid of modern plant breeding and the scientific application of fertilizers, rice has been made to yield there as much as 60 quintals per hectare [3] (23 in the U. S , 35 in Japan, and from 10 to 15 in most other parts of the Far East) The areas where rice could be grown are much larger in North America than in Europe. In many parts of the warm rainy South the natural environment is quite favorable, in fact, before the Civil War it was grown with the aid of slave labor as far north as South Carolina It has not, however, become an important crop in the South, because of the minor role which it plays in the white man's diet and the amount and the disagreeable type of labor involved in its cultivation A solution of the labor problem, with modern methods adapted to American aims of high production per worker instead of high yield per unit of area, has been attempted on the low, black coastal prairies of Louisiana and Texas, on the delta lands of the Mississippi, and in the valley of California. The results have been so successful that at present the United States produces more rice than it needs for

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[3] One quintal equals 220 pounds, one hectare is 2 47 acres

home consumption. The surplus is exported in successful competition with that grown under primitive oriental conditions, because of the high quality of the American product.

World production and international trade.—Although accurate data are wanting, it is estimated that the world production of rice may safely be placed at about 1,300,000,000 quintals annually. On that basis the world's rice crop exceeds that of corn and in some years may well exceed that of wheat Since rice is grown on a small scale for local consumption the international trade does not attain the importance of that in wheat Nevertheless, world trade has been growing steadily in recent decades and is of vital importance to the continent of Asia.

Rice is the main food of the wheatless multitudes of the Far East and the Middle East In those regions it is what white wheat bread is to the European, the most desirable but also a relatively expensive food. In the densely populated areas of southern and central China, Japan, and Java, production is not sufficient to meet demands, even though part of the population is too poor to eat it regularly. These are the principal importing countries, to which may be added the Philippines, the Outer Provinces of Netherland India, and western Europe. The Philippine Islands and the Outer Provinces of Netherland India easily could produce sufficient rice for domestic requirements, but the interest of the population lies more in the direction of cash exports. Nearly all the countries of western Europe are large importers of rice because their populations were taught its use as a food when early colonial ventures made it available at comparatively low prices

The regions of surplus production of rice are characterized by exceptionally favorable physical environment and by moderate density of population. India and Ceylon obtain most of their imported rice from Burma, as Japan obtains most of its imports from its possessions, Formosa and Korea French Indo-China, Siam, and Burma sell not only to other Far Eastern countries but also to Europe. A large percentage of the rice sold in the East is handled through and distributed by the two great entrepot ports of Hongkong and Singapore The only

other Oriental exporters which need be mentioned are Egypt and Persia The producing regions in Europe and North America raise excellent qualities of rice, and all have considerable quantities available for exports Rice from the United States is exported to the island possessions, Porto Rico and Hawaii, and to Europe, while that of Italy and Spain goes to other European countries The consumption of rice for food and for industrial purposes, as flour and starch, has called into life a milling industry in several western countries. Since the World War, however this industry has been struggling against the tendency of having most of the milling done in the countries of export, where modern machinery has been introduced.

TEA

The tea shrub (Thea sinensis) is a broad-leaved evergreen whose distribution is limited to areas where there is no cold season. It is, however, tolerant of a wide range of warm temperatures, such as prevail in the tropical and subtropical regions In fact, the tea bush has been known to survive as far north as southern France, and it could undoubtedly be grown in southeastern United States.

Since the tea shrub is moisture loving, its commercial cultivation is confined to rainy tropical and humid subtropical regions. The teas of commerce consist of the dried young leaves and tender sprouts of the shrub, and the vigorous growth necessary to provide such an adequate supply is possible only where rainfall is ample and dependable and the air constantly humid.

The tea industry requires an abundant supply of cheap labor. Plucking the leaves is at best a tedious task, but nevertheless one that requires considerable skill It is improbable that any kind of machine can ever be devised to perform this work. Successful tea plantations can, therefore, be established only where density of population is high and the standard of living relatively low. These factors, environmental and economic, together with that of historical development, are responsible for the concentration of the commercial tea industry of the world in the countries of eastern and southern Asia.

Historical development.—The leaves of the tea bush were prized for their medicinal qualities by people in eastern Asia long before they were used for beverage purposes. Because of its aroma, flavor, and stimulating qualities, the Chinese began to use tea as a beverage as early as the seventh century A.D. The necessity, moreover, of being extremely cautious with drinking water and the practice of boiling it to avoid spread of contagion under their warm and unsanitary conditions may be

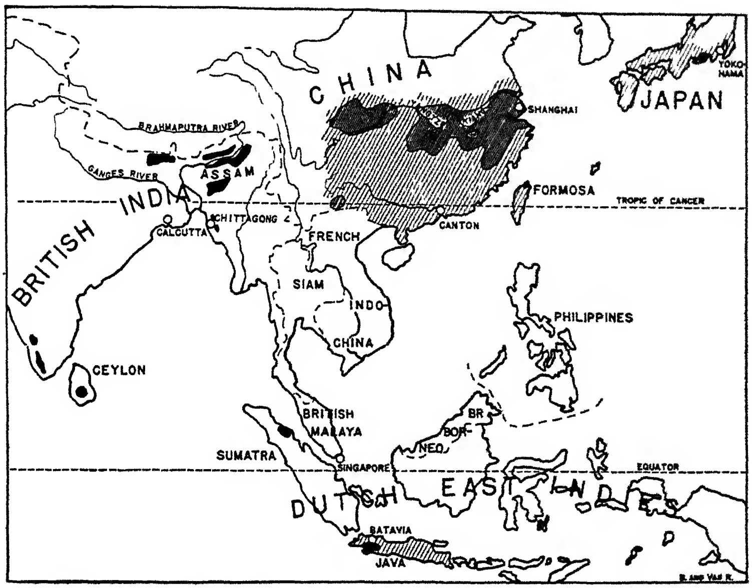

Fig. 233.—Principal tea producing regions of the world and chief exporting cities.

partly responsible for the early popularity of tea among the Chinese. From the Far East this use of tea spread to Europe and other parts of the world. From a luxury, which only the aristocracy and the wealthy merchant class could afford, it later became a necessity and therefore an important article of world trade. At present production of tea for the world market is concentrated in British India, Ceylon, Netherland India, China, and Japan.

There are two main varieties of the tea plant, the Chinese and

the Assam. The latter was discovered wild by the British in northeastern India and has been domesticated into a cultivated plant. It grows taller and has much larger leaves than the Chinese variety While China and Japan grow the Chinese variety exclusively, British India, Ceylon, and Netherland India cultivate the Assam tea

Distribution and commercial production.—British India is the principal tea exporter of the world The industry centers in the flat, alluvial lands on either side of the Brahmaputra River and in the region immediately south of the Assam Hills

Courtesy, Indian Tea Cess Committee

Fig. 234.—Modern tea plantation, Assam, British India. Buildings in middle background make up the processing plant. Heavily forested mountains in background.

This part of the country has exceedingly high rainfall, averaging from 80 to 100 inches per year in the tea regions proper. High humidity, heavy dews and morning fogs, and the complete absence of dry winds favor rapid development of young leaves. From December to February, however, this part of India has a cool and rather dry season, at which time the shrubs remain dormant During the remaining nine months leaves can be picked every eight or nine days Another important tea area is located in the foothills of the Himalayas, south of Darjeeling, in the so-called Dooars. Around Darjeeling itself tea is grown at

altitudes up to 4,000 feet The slow growth of the plant in this region, because of the lower temperatures, leads to the production of a very high grade of leaf The yield per acre, however, is considerably less than that in the lowlands

In southern India tea is grown along the rainy west flanks of the Ghats Mountains. There, as well as in neighboring Ceylon, plantations lie at greater altitudes than in northern India No unfavorable season interferes with the growth of the leaves, and picking can continue throughout the year

Although tea is grown in all sections of Java, production is most intensive on the fertile volcanic soils of the higher districts of West Java, where rainfall is plentiful at all seasons. In recent years the Deli district on the east coast of Sumatra has also become an important producing area

In all these areas the attention of the planters is nearly exclusively directed toward the production of black teas These require fermentation of the leaf, along with withering rolling, and firing, while the green types have not been allowed to ferment The Assam variety contains a rather high percentage of tannic acid (tannin), and although the fermentation process eliminates nearly half of this, sufficient is left to impart to the beverage a strong flavor and a certain pungency which please Western consumers

The Chinese tea, grown principally in China, Japan and Formosa, gives a much more delicate product than does the Assam variety. It is made into green as well as into black tea. In China, production centers in the hilly belts which surround the Yangtze basins

During the summer months the monsoon winds bring considerable precipitation to all of southern China, and this, together with high temperatures, favors the flushing of the tea bush In most districts there are three harvests one in the early spring (March, April) furnishing first quality leaves, the so-called Pekoe; the second in the early summer (May, June) yielding leaves of medium quality; and the third harvest in late summer (August, September), one of decidedly inferior quality which does not enter world trade. The production is

in the hands of small farmers who devote most of their time to the cultivation of foodstuffs and grow tea only on lower slopelands not suitable for other crops. This large number of miniature tea gardens and the nearly complete absence of modern plantations results in an extremely heterogeneous product Furthermore, the methods of manufacture are rather antiquated. While as late as the end of the last century China was the world's most important exporter of tea, the exports have declined greatly as a result of the competition of other producing areas.

In Japan tea production centers on the Pacific side of southern Hondo, Shihoku, and Kiushiu. This part of Japan has milder winters and receives considerably more rain from the monsoon winds than does the west coast. The growing season lasts from six to eight months and, as in China, three to four pickings are possible Much of the tea is found in the foothills and on higher terraces, where there is less competition from other crops The exports consist entirely of green teas. Formosa is well-known because of its production of a semi-fermented tea, called oolong.

Tea is a typically English drink More than three-fifths of that which enters world trade is exported to parts of the British Empire It is therefore quite logical that the principal trading center of the world should be in London, in the well-known Mincing Lane district The only other country outside the British Empire with a high per capita consumption is the Netherlands. Although Russia is the land of the Samovar, tea has remained a product consumed chiefly by the more well-to-do. Most of the tea imported into the United States originates in British India, Ceylon, and Japan Minor quantities are imported from Netherland India and China

SILK

Among the various textiles, silk is by far the most expensive —in fact, it may be considered a de luxe product which even now only the richer countries in the world can afford to buy in large quantities In China, the classical land of sericulture, the

wearing of silken garments was long the exclusive privilege of the upper classes Silk and spices were the principal products which reached southern and western Europe from the Orient during the Middle Ages. In many European countries of those times the use of silk in clothing was one of the prerogatives of the nobility and the higher clergy.

Silk is the product of the caterpillar of a moth (Bombyx mori) which spins itself a cocoon of silken threads when the time has come for its metamorphosis This caterpillar, usually referred to as a silkworm, has the distinction of being one of the very few insects that, with some measure of truth, can be ranked with domestic animals It feeds exclusively upon the young leaves of the mulberry tree, preferably the white variety. Sericulture, therefore, is directly dependent upon the cultivation of this tree

Distribution.—Although the white mulberry can be grown quite far north, it is primarily a tree of the regions with a humid subtropical climate Only where the winters are comparatively short and mild, the summers warm, and moisture fairly abundant does it form young leaves in sufficient quantities to support large-scale rearing of silkworms. The trees are pruned so as to assume bush forms, in order to facilitate the gathering of the leaves. Since the tree grows fairly well even upon poor soils, the mulberry groves can be relegated to rather mediocre sandy or gravelly areas, or to steep slopelands, thus leaving the better lands for food crops

The actual rearing of the silkworms is nearly always carried on in the farm homes or in specially constructed sheds. Although in this way a certain measure of protection can be provided against inclemencies of the weather, silkworms cannot be raised economically where it is too cold or too warm and humid In general, it may be said that the silkworm needs temperatures which during the breeding season never fall below 60°F ; this limits their cultivation largely to regions with a subtropical climate.

As far as climatic conditions are concerned, large areas in the world are suitable for sericulture. The southern part of the

United States, for example, has a climate in which both mulberry and silkworm can thrive. Nevertheless, sericulture is conspicuously absent in this country; in fact, the industry is limited to a few regions in the world. The reasons are mainly economic and social The rearing of silkworms is tedious work, requiring infinite care and patience and demanding vigilance both day and night. It can be carried on successfully only if a large amount of cheap and conscientious labor is available Thus, the raising of silkworms is usually a family industry which is found in regions with a crowded agricultural population, where the land alone cannot adequately support those living upon it, and where a certain number of hands are free to devote themselves exclusively to the exacting needs of the silkworm.

China and Japan are the greatest silk producing countries of the world In China the industry centers in the densely populated drainage basin of the Yangtze River and in the coastal districts west and south of Shanghai Considerable quantities of silk are produced also in the delta region of the Si-kiang, near Canton, and in the Shantung Peninsula So-called wild or tussore silk, the product of a caterpillar which lives on oak trees, is produced in the Shantung and Liaotung Peninsulas. True pongee is woven from this kind of silk

In Japan sericulture is practiced as far north as the island of Hokkaido. Most of the silk, however, is produced not on the fertile coastal plains but in the rugged mountain areas of central Hondo, where good agricultural land is scarce, and where population is so dense that it has to look about for means to supplement the meagre income derived from ordinary crops.

As a rule, sericulture in both China and Japan is carried on in conjunction with other agricultural activities, the burden of work usually falling upon the women and children Statistical data concerning the industry are incomplete and in some cases unreliable, hence estimates of annual output are subject to considerable error It is probable, however, that the continent of Asia produces nearly 95 per cent of all the silk in the world While China was formerly the principal exporter of silk, now,

as a result of great improvements in sericultural practice and in expansion of its silk trade, Japan holds first place. Centers of minor production in Asia are Korea, British India, Russian Turkestan, Persia, and the Near East. In Europe, silkworms are raised in northern Italy and southern France However, the French production of raw silk is slowly declining.

Production.—The cocoon which the silkworm spins may contain from 300 to 600 yards of filament. The unwinding of the cocoons and the uniting of the filaments from three to ten or more of them into one final thread of raw silk is called "reeling" This process also requires a considerable amount of patience, dexterity, and attention to detail. In many regions, especially in China, the cocoons are reeled in the home. In the more advanced silk producing centers this process takes place in small reeling establishments provided with mechanical power, which are scattered through the countryside, each one taking care of the cocoons produced in the neighborhood. These establishments are commonly referred to as *filatures*. The product of the filatures is the so-called raw silk

Raw silk is an exceptionally light material. This, of course, greatly enhances its value per unit of weight As has been mentioned before, because of its small bulk and high value, silk—especially cloth—was for centuries one of the principal products of trade which reached the Western World from the Orient.

At present, although silk textiles are widely manufactured in China and Japan for domestic use and even for export, probably half of the total production of raw silk moves from the producing countries to the centers of manufacture in the occidental countries. The manufacture of silk textiles depends not so much upon the availability of cheap power as upon the presence of a body of highly skilled workers and proximity to a large and prosperous market.

Among the centers of consumption the United States, with its great per capita wealth, easily ranks first Since, happily, economic and social conditions preclude production of silk here, the United States must import all of its raw material In recent years it has absorbed almost the entire raw silk exports

of Japan, while smaller quantities have been imported from China, Italy, and some other countries The manufacture of silk textiles is concentrated in Pennsylvania, New Jersey, New York, and southern New England Important centers of manufacture in Europe are the districts around Lyons and Milan; smaller centers are found in and around Zurich, Switzerland, and Crefeld, Germany.

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CHAPTER XXI

The Regions of Humid Intermediate Climates, I: Continental Types

BETWEEN the belts of all-year warm climates and the all-year cold is a belt marked by vigorous seasonal extremes. In general, there are two major groups of climatic types within this belt. the humid and the dry. The humid climates have rainfall sufficient to promote a native flora of forest or tall grass; the dry climates have an annual rainfall of less than 20 inches and the native vegetation is of the steppe type, consisting of either short grass or scattered bush. In this chapter only the humid intermediate climates are considered

General characteristics of the humid intermediate climates.—The humid intermediate climates most typically developed are those of North America and Eurasia In the Southern Hemisphere the middle latitudes are chiefly oceanic, the land masses are mostly tropical or polar. A glance at the map of climatic regions (Fig. 300) will reveal the dominance of two types in the middle latitudes of North America and Eurasia—namely, the humid continental climate with short winters and that with long winters. These types are greatest in extent, have great amplitude of seasonal temperatures, and the maximum rainfall occurs during the warm season. Flanking these extensive regions to the east and west are climatic types which have been modified by the bordering oceans, while to the north lies a belt which forms the transition zone between the true intermediate and the polar climates.

There are therefore five recognizable types of humid intermediate climates, two of which are the well developed continental types and three which are modified or transitional The former group embraces those already mentioned the humid

continental climate with short, cold winters and long, hot summers, and that with long, cold winters and short, hot summers. The latter group includes three types: namely, (1) the modified continental of the east coasts, such as that of New England and Japan; (2) the marine and littoral of the west coasts, such as that of the North American coast from Oregon to Alaska, and that of northwestern Europe; and (3) the northern transitional, subpolar in its characteristics, which dominates much of Canada, Sweden, Finland, northern Russia, and Siberia. All five of these types have rainfall sufficient to develop native vegetation of forest or tall grass and, where other conditions permit, to support crop farming The seasons are based on changes in temperature rather than on distribution of rainfall All may be said to have climatic conditions which stimulate mental and physical activity In this chapter the humid continental types are studied; the others are taken up in the chapter following.

THE SHORT, COLD WINTER—LONG, HOT SUMMER TYPE OF CLIMATE

The humid regions having short cold winters and long hot summers are limited to North America and Eurasia. In the United States this type of climate roughly coincides with the areas where corn and soft winter wheat are the leading crops; in Europe it includes most of the drainage basin of the Danube River and part of the Polish Plain; in the Far East it embraces northern China and Korea. In the United States this type is often referred to as the corn belt climate because corn is the dominant crop.

Temperature.—The average temperature of the coldest month is below 42°F., but not more than three months have averages which drop below freezing. The average temperature of the warmest month is at least 36°F higher than that of the coldest month, and in many places the difference is even greater These extremes are generally not so severe as to cause serious discomfort. On the contrary, the seasonal amplitudes are stimulating to mental and to physical activity.

ditions of the prevailing westerlies, but in eastern Asia the summer and winter monsoons are so strongly developed that they partly conceal the moving highs and lows. The cyclonic storms are strongest in winter because their paths then lie farthest south As a result, fluctuations of temperature are much greater in this season than during the summer months. Occasional cold waves sweep down across the American Corn and Winter Wheat Belts with such stormy violence that locally they are referred to as blizzards On such occasions mild, balmy weather gives way suddenly to zero temperatures, a blinding snowfall, and piercing winds During pioneer times people were often caught unprepared, because of the suddenness of changes, and therefore personal suffering and serious losses of livestock resulted from these storms. With the development of weather warnings broadcast by radio, most of the danger can be avoided, since the direction, progress, and duration of severe storms are predicted quite accurately Farmers and ranchers, thus forewarned, are able to provide feed and shelter for the stock while the storm rages

In summer, on the other hand, the most feared weather phenomena, especially in the plains west of the Mississippi, are the hot winds. Occasionally low pressure areas centering in the upper Mississippi Valley move so slowly that they appear to be almost stagnant Then southerly winds continue for days over the plains from Texas to Nebraska, bringing with them soaring temperatures When the land is dry, temperatures often exceed 100°F and occasionally reach above 115°F, with blasting effects upon growing crops and serious damage to trees and grass The summer of 1934 was an example of the extremely serious effects of such winds when attended by continuous drought.

During spring and early summer, when air conditions are unstable due to the change from cold to warm season, violently whirling air masses occasionally develop within the cyclones. These whirls, known as tornadoes, are among the most destructive storms known. Although of much smaller diameter than the tropical hurricane, the path of maximum destructiveness

seldom being more than half a mile wide, tornadoes in some cases reach such wind velocities that only the sturdiest structures are able to withstand their attacks Some claim that no structure ever erected could withstand the force of a fully developed tornado The validity of such a claim may be doubted,

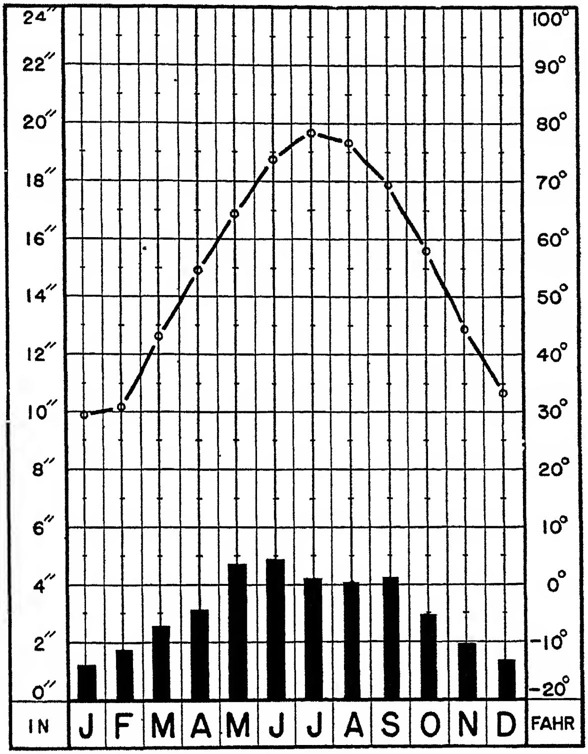

Fig. 236.—Short, cold winter climate. Average temperature and precipitation, Kansas City, Missouri. Altitude 963 feet, total precipitation 37 inches.

but there is no doubt that tornadoes usually cause terrific damage all along their paths

Precipitation.—The average annual rainfall varies from about 20 inches in the drier areas to 50 inches in the more rainy sections. In general, the amount of rainfall varies inversely with distance from the sea. Summer maxima of rainfall are prevalent nearly everywhere in the humid continental climate with long summers, but decidedly dry winters are typical only

of the American interior west of the Mississippi and of northern China The well developed summer maxima are a factor of great importance in accounting for the successful crop agriculture of interior areas where the annual rainfall is only 20 to 35 inches; since 65 to 75 per cent of it falls during the summer season, its efficiency in promoting plant growth offsets in large measure the handicap of a low total In areas relatively near the seaboard not only is the annual precipitation greater but the seasonal distribution is more uniform than in the interior, this being particularly true of North America.

In the comparatively dry areas where this type of climate prevails, as well as farther north where the long, cold winter type is dominant, variability of rainfall is great and important. The effects of such variability are much more evident than where the total precipitation is higher Sometimes several years in succession may have rainfall so far above normal that streams overflow, wet weather ponds become all-year lakes, and lowlands are flooded for such long periods that crops are damaged or even ruined. Then many people, convinced that a great change in climate has occurred, start agitations for drainage projects Under the impulse of such misguided notions many miles of unneeded drainage ditches have been constructed at great expense Later on, when dry years come, as they inevitably do, either singly or several in succession, crop failures and pessimism go hand in hand Many then believe that a permanent drought has set in and that the country is destined to become a desert waste Instead of drainage, the construction of dams to impound water for irrigation purposes becomes the popular cry In each situation, whether flood or drought, the popular mind is likely to be stirred by the immediate outlook rather than quieted by the facts of long-term records The fluctuation of rainfall is eloquently attested by the records of the Weather Bureau These show that dry years have always been followed by years of greater rains; years of heavy rainfall have always been followed by years of less rainfall. It seems safe to assume that such a condition is permanent as far as the

decades to come are concerned Human activities, agricultural or industrial, should be organized and operated in recognition of this fact.

Native vegetation.—The dominant native flora consists principally of deciduous forest in the more humid sections and tall grass prairie in the areas of lower rainfall. In China and Europe the land has been under cultivation so long that, except in the higher mountain areas, but little of the native vegetation remains. In the United States the prairie was originally the conspicuous feature of the landscape from Indiana to central Nebraska and from southern Minnesota to the Ozarks of Missouri. Although the best agricultural lands, especially the prairie lands, have quite generally been put into cultivation, there are still large tracts where the native vegetation covers the landscape. The forest is principally of the mixed hardwoods type, with oak, hickory, chestnut, and ash predominating. Pines are found on some of the more sandy lands, but pine forests are not so extensive as in the warmer region to the south or in the colder region to the north.

Soils.—The predominant soils are the brownerths and the gray-brownerths. In these leaching has not been quite so pronounced as in those of the humid subtropics, partly because of lower annual rainfall and partly because during the winter season the ground is frozen for some time, thus making the water in the soil inactive. The lower annual temperatures, and particularly the seasonal cold, account for less effective oxidation than in warmer climates, and therefore the soils are brown rather than red.

In the United States this climatic region includes vast plains areas where the soils have been developed from rocks of high lime content, and where their structure still shows the beneficial influence of the former presence of lime even though leaching has removed most or all of the calcareous elements from the upper horizon. Such are the mature upland soils from central Ohio to central Iowa. Wolfanger classifies them as "calcific brownerths" and praises them as "a subgroup [of the mature

gray-brownerths] without a worthy equal."[1] These calcific types are characterized by a stable structure that enables them to remain in good physical condition under cultivation. Although low in lime and other soluble minerals in the A and B horizons, they are responsive to fertilizers and thus have the essential favorable qualities for successful crop agriculture

In the eastern and southern portions of this climatic region of the United States, where winters are generally mild and the rainfall is fairly heavy (40 inches or more), the soils are more thoroughly leached and the color is somewhat deeper brown than in the calcific brownerth area. The structure is quite stable, in fact the strong physical constitution of the soils is their greatest asset Fertilizers are effective and hence need not be used in such large quantities as where weaker, less responsive soils are found. These non-calcific brownerths are the soils which are most extensively developed from central Ohio eastward.

In the areas where tall grass rather than forest prevailed, deep, dark, friable soils occur. These are known as *prairyerths,* because they have developed under grass cover; their A horizons are of deep dark brown color, owing mainly to the high content of organic matter Although the prairyerths are classified as pedalfers, because they are non-lime accumulating, they are but slightly leached and so are productive with little or no use of fertilizers. These soils are dominant from Illinois to eastern Nebraska and they include some of the best farm lands in the United States.

On the whole, the regions where the humid continental climates with short cold winters prevail are favored with soils of high agricultural potentialities Although they are mostly pedalfers, neither leaching nor oxidation has been excessive, soil structures are quite stable, and the organic content is comparatively high. On most of the mature soils mineral fertilizers are needed, but their responsiveness is such that moderate

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[1] Wolfanger, L A "Economic Geography of the Gray-Brownerths of the Eastern United States," *Geographical Review,* Volume XXI (1931), p 280

amounts suffice to insure good yields of the common cereal and forage crops.

General aspects of land utilization.—Wide diversity of crops is characteristic of regions having this type of climate In Eurasia corn is of major importance only in some of the Danubian countries, whereas in the United States it is the main crop In China, wheat, millet, and beans are the principal subsistence crops of a great population There, with the use of simple, almost primitive, equipment, agriculture is carried on by hand labor methods. Production per capita is low, but all

Photo by N A B

Fig. 237.—The tall grass prairie of eastern Kansas, the Chikaskia Valley, in the region of dark prairyerth soil. Native flora now occurs only in strips not farmed along roads.

available land is fully used in order to support the masses of people dependent directly upon it, and the total production is large Pressure of population upon the land is so great, however, that no surplus can be produced As a result the peasants have little or no resistance, and famine is a recurring phenomenon

In Europe, wheat, corn, and root crops constitute the basis of a successful agriculture carried on largely by modern methods, but with machines of small size and simple design compared with the larger and more complex equipment used on the more extensive farms of the New World

In the United States, corn is king in this region. From an American point of view the short, cold winter—long, hot summer type may well be called the corn belt climate, because the area extending from Ohio to eastern Nebraska and from southern Minnesota to the Missouri Ozarks is by all odds the greatest corn producing region in the world. However, it is not a one-crop region. The farmers raise not only corn but also large quantities of oats, wheat, root crops, and forage, particularly legumes. South of the Corn Belt proper lies a zone of transition from the humid intermediate to the humid subtropical climate which is also a transition zone from corn to cotton. There soft winter wheat is of such importance that it runs corn a close race for first place Within this transition zone are located the famous tobacco producing areas of Virginia and Kentucky, the two greatest tobacco growing districts of the United States. North of the Corn Belt proper the climatic transition to the long winter type is marked by a gradual increase in the importance of oats, soft spring wheat, root crops, fodder crops, and dairying.

THE LONG, COLD WINTER—SHORT, HOT SUMMER TYPE OF CLIMATE

This type of climate lies poleward from that discussed previously It prevails in north-central United States from New York state to South Dakota, north of the Corn Belt, and extends northward to include south-central Canada. The soft spring wheat belt and the hay and dairy sections lie almost entirely within this region. In Eurasia the long, cold winter—short, hot summer climate is well-developed in a broad belt which extends from eastern Poland and the Baltic States across central Russia into southern Siberia. An area of similar climate occurs in Manchukuo. As was the case with the short winter type, this climate is not represented in the Southern Hemisphere.

Temperature.—The characteristics of the two humid continental climates are similar in many respects, but they differ markedly in one respect—namely, in the length of the growing

season. The long, cold winters of the climate under discussion preclude the production of slow-maturing crops and the growing of fall sown grains.

In areas having the long, cold winter type of climate the average monthly temperature drops below freezing (32°F) more than three months each year, but during the summer season at least four months have averages above 50°F. The annual averages are somewhat lower than those in the short cold winter type. For example, at Winnipeg the annual average is 38°F. as compared with 50°F. at Omaha. Likewise, both summer and winter averages are lower. The absolute summer maxima may be nearly as high in the long winter type as in the short winter type, but in the former the hot spells are of much

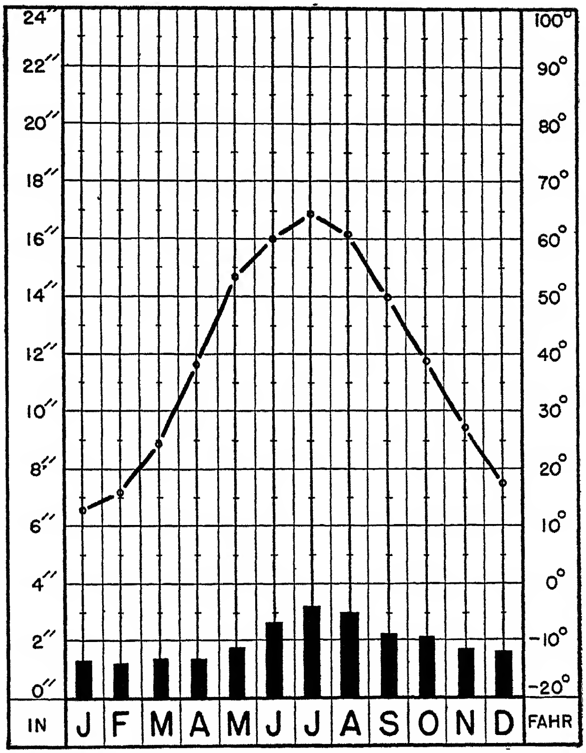

Fig. 238.—Long, cold winter climate. Average temperature and precipitation, Moscow, Russia. Altitude 492 feet, total precipitation 24 inches.

shorter duration. The minimum of winter is likely to be lower —occasional records of -30° to -40°F. are not uncommon—and the cold spells last longer than in the short, cold winter type. The major factors which cause the great seasonal extremes of temperature in this climate are distance from the ocean and the great difference in the length of day in summer and winter. In

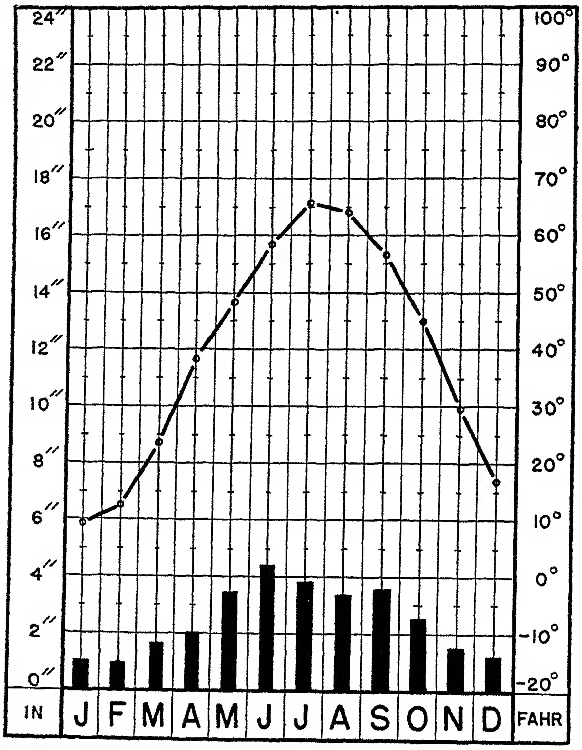

Fig. 239.—Long, cold winter climate. Average temperature and precipitation, Duluth, Minnesota. Altitude 1,133 feet, total precipitation 29 inches.

midsummer there may be 15 to 18 hours of sunlight, whereas in midwinter the sun is above the horizon only 6 to 9 hours daily The growing season is short; frosts may be expected late in the spring and early in the fall In many localities not more than three or four months are free from killing frosts At Winnipeg, for example, the growing season lasts only from June 1 to September 1

Winds.—Two factors—namely, the cyclonic storms and the monsoons—are of outstanding importance in the wind regime of the long, cold winter climate The chief factor in North America and Europe is the location of the region in the path of cyclones and anticyclones. In the northern interior of North America a fairly persistent area of high pressure develops during the winter; this forces the storm paths to the southern part of the long, cold winter region or even beyond it Cold, northerly winds, which often last for days, are the result In Asia the monsoons dominate the weather, while cyclonic wind movements play a minor role. The high pressure area of eastern Siberia causes strong out-blowing winds in winter, while in summer the pronounced low pressure area gives rise to persistent in-blowing winds.

During the winter eastern Europe is under the direct influence of the Asiatic high pressure area, which forces the lows from the Atlantic Ocean to take a northeasterly course. These moving lows bring sharp changes of temperature, often veritable cold waves and blizzards, there called *buraus*. Occasionally the Asiatic high pressure becomes so pronounced that it extends westward to Russia. At such times prolonged periods of dry, clear, and cold weather prevail.

Precipitation.—On the average the annual precipitation is lower in the long, cold winter type of climate than in the short winter type. It ranges generally from 15 inches in the portions which lie farthest from the oceans to 25 inches in the more humid parts The scantiness of the annual rainfall is offset by two favorable aspects—namely, its distribution and its efficiency in promoting plant growth. About 40 per cent of the precipitation falls during the short growing season, June to August inclusive The efficiency of the rainfall is high because, owing to lower summer temperatures, the evaporation is not quite so great as farther south. That the snowfall is greatest nearest the ocean is shown in North America, where it increases eastward through the hay and dairy belt to near Montreal In the heart of the North American continent the total snowfall is not great, but that which falls accumulates for long periods of time and forms

a protective blanket for the soils In Europe the regions near the Baltic have the heaviest snows In Manchukuo, snowfall is light because of the prevalence of dry, out-blowing winds from the interior

Thunder showers are common in the summer, although they are less frequent than in the short winter climates Blizzards are characteristic aspects of the long, cold winters, and they are more numerous than in the climate with short winters

Vegetation.—The native vegetation consists largely of prairie grasses in the drier portions and forests in the more hu-

Photo by N A B

Fig. 240.—Native prairie land on Lake Agassiz plain near Moorhead, Minnesota. Crop farming in distance.

mid. The forests are composed of the hardier deciduous trees, with coniferous trees on the sandier, stonier, or higher grounds In general, the pines thrive on the drier soils, and firs and spruces on the more humid soils

Soils.—The gray-brownerths, previously described, are the principal soils in the southern parts of this climatic region where relatively warm and humid conditions prevail. Their color gradually becomes more grayish where cooler temperatures prevail, but their general composition and structure remain fairly uniform. The change in agricultural practices typified by the shift from corn to rye and spring wheat is a response

to decrease in length of growing season rather than to soil differences.

In the northern section of the region in North America, extending from northern Minnesota eastward and including the adjacent part of Canada, and in a large part of the Russian area, leached gray soils, known as *podsols,* are predominant The name is an old Russian folk term which has long been applied to the gray soils so extensively developed in northern Russia; it is derived from the words *pod,* or soil, and *sola,* meaning ash. The podsols are acid soils, deficient in mineral and in well de-

Photo by N A B

Fig. 241.—Deciduous forest of mixed hardwoods, northern Wisconsin.

cayed organic matter The surface layer is raw humus, made up of mosses and partly decayed leaves and sticks, and may reach a thickness of a foot or more. This layer really lies on the surface The upper soil, the A horizon proper, underneath this is gray to white in color and of comparatively open texture. The structure is usually simple, either platy or granular. The B horizon, or subsoil, is dark brown in color and quite compact, owing to precipitation of organic matter and iron compounds leached from the upper soil

With only lime added the virgin soils often yield quite well for two or three years because of the plant nutrients found in the capping humus layer This, however, is soon exhausted,

and then heavy applications of mineral fertilizers are necessary to maintain productivity.

In the areas which are transitional between the humid and semi-arid lands, prairyerths and blackerths are found Notable examples of these soil areas occur in western Minnesota and the eastern Dakotas and extend northwestward into the prairie provinces of Canada. Another very large area of these soils lies in southern Russia, from the Carpathians to the southern Urals and thence into southern Siberia These soils are highly productive without the use of mineral fertilizers They are easily tilled and support a profitable system of crop farming based on the limitations of low rainfall and short growing season.

Land utilization.—Crop production of cereals is limited almost entirely to those which can mature in a short season Flax, barley, and spring wheat are the typical grain crops. Flax, grown only for seed in North America, is produced also for fiber in Russia Sufficient moisture during the earliest period of growth, large accumulated temperatures during the long days of the short growing season, and warm, dry weather during the harvest season are factors favorable for the production of wheat and barley of excellent quality Rye is the fall-sown grain Corn is grown chiefly for silage or fodder because of the danger that it will not reach maturity. Some legumes, especially clover, and tame grasses are of importance as fodder crops Root crops do especially well in this climate In regions where little or no corn is raised, potatoes are not only a staple food for people but they are also used extensively as feed for livestock Some districts are important for sugar beets The yield per acre is generally less than where the summers are long, but this is offset by the higher sugar content which results from the long periods of daily sunlight in summer.

While, on the whole, this type of climate must be rated somewhat below that of the short winter type in its agricultural possibilities, it is nevertheless an energizing climate that promotes profitable productivity Within its domain live some of the most vigorous peoples on earth—for example the Canadians and Russians Within the United States the area from North

Dakota through Minnesota, Wisconsin, Michigan, and New York is recognized as being one of the most productive and most progressive sections of the country.

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CHAPTER XXII

The Regions of Humid Intermediate Climates, II: Marine and Transitional Types

THE types bordering the humid continental climates are, of course, transitional between higher temperatures on the south and lower on the north Toward the coasts the influences of the great oceans are felt, as they moderate the heat of summer and the cold of winter Inasmuch as the intermediate climates are in the belt of prevailing westerly winds the oceanic influence is pronounced along the west coasts of North America and Europe where it gives rise to a marine phase Along the east coasts this influence is not so pronounced, because air masses from above the oceans are carried inland only during periods of easterly and southerly winds caused by passing cyclonic storms and by in-blowing monsoon winds Thus, while along the west coasts in the middle latitudes a distinctly marine type of climate prevails, along the east coasts the climate has both continental and marine aspects and therefore is called the modified humid continental type

THE MODIFIED HUMID CONTINENTAL CLIMATE

This type of climate occurs along the east coasts of North America and Asia between 35° and 50° N latitude It is well developed in North America from New Jersey to Newfoundland and along the Asiatic Coast from central Hondo northward The Southern Hemisphere has no areas of this type of climate because the land masses projecting into the corresponding latitudes are not sufficiently extensive to develop the great seasonal extremes of temperature which characterize the central portions of North America and Asia

Temperature.—Although the average annual temperatures

are about the same as those in the corresponding latitudes of the continental interiors, the seasonal extremes are more moderate For example, Eastport, Maine, with an annual temperature of 41 4°F has an average January temperature of 21°F. and an average July temperature of 60°F. St Paul, Minnesota, in about the same latitude, has an average annual temperature of 44°F , but its January average is 9 degrees colder and its July average is 12 degrees warmer than that of Eastport Spring opens up later in east coast climatic regions than in the corresponding continental interiors, the last killing frost usually occurring two or three weeks later. Autumn is also retarded, but usually not so much as the spring

The annual average temperature is somewhat lower than in the west coast climates in corresponding latitudes, but the seasonal range is considerably greater The annual average temperature at Portland, Maine, (46°) is only six degrees lower than that at Portland, Oregon, in approximately the same latitude, but the January average is 17° lower, while the July average is 1° higher Thus, on the windward coasts the summers are almost as warm but the winters are not nearly so cold as those on leeward coasts in higher middle latitudes

Winds.—As in the continental climates, two major wind conditions are dominant that of the cyclonic storms with slight monsoonal influence in North America and that of the strong monsoons slightly modified by cyclones in eastern Asia In summer the strong on-shore winds from the Pacific modify the summer temperatures of Japan, but in winter the considerably stronger out-blowing winds reinforce the westerlies and accentuate the tendency to low temperatures at that season The temperatures of the winds are, however, modified somewhat in crossing the Sea of Japan.

Cyclones and anticyclones bring marked variability, particularly in North America, where their influence is most strongly felt When winds are from the east they bring to New England and maritime Canada quantities of damp air from the ocean which give rise to periods of piercingly chilly weather in winter In summer the winds from the ocean are cool and pleasant along

the shore but, because of their high moisture content, they tend to become oppressive and enervating farther inland where land temperatures are higher.

Rainfall and humidity.—The precipitation, which generally amounts to 40 to 80 inches annually, is distributed throughout the year In New England it is fairly evenly distributed, there being at Boston, Massachusetts, only .9 inch difference between the wettest month and the driest month. In Japan, however, there are sharp contrasts between the east and west coasts. The west coast of Honshu receives its maximum rainfall in early winter (December) while the east coast has heaviest precipitation during summer and early autumn, September being the rainiest month. Hokkaido, farther north, has a double maximum during May and September. At Niigata, on the west coast of Honshu, less than 300 miles north of Tokyo, hardly a day passes in winter without rain or snow On the uplands, 15 to 20 feet of snow yearly are reported Cloudiness is almost continuous during winter along the west coast, whereas clear skies then prevail over Tokyo and the east coast lowlands In summer the conditions are reversed Tokyo then has its season of clouds and rain, whereas the west coast lands receive little rain

The amount of precipitation is particularly noticeable in the winter snows; in New England the snowfall may exceed 80 inches in a single season and remain on the ground for four months These heavy snows necessitate great expense and labor in keeping the highways open. Overland communication is almost discontinued during the worse snow storms Ice and sleet storms occasionally cause great damage to trees and to telephone and telegraph lines. The cyclonic storms tend to converge toward an area lying between the 40th parallel and the St Lawrence Valley Great variability of weather, expecially sudden changes in temperature, are characteristic for this region Thunder storms are not uncommon, but the greater part of the rain falls in gentle showers unaccompanied by lightning Tornadoes are rare and blizzards such as occur in the humid continental climates are unknown. However, the heavy snowfalls and low sensible temperatures which characterize the

"northeasters" often cause much inconvenience and physical discomfort

In northern Honshu and part of Hokkaido, Japan, winter snows are exceptionally heavy, so heavy in fact that the roofs of houses must be designed specially to shed the load. Ofttimes the snow is so deep that great efforts are necessary to keep the highways open

Vegetation.—The native vegetation of the regions having this type of climate is a response to the smaller amplitude of temperature and to the abundant and even distribution of precipitation In winter, heavy snows usually protect the soils from extremely low temperatures, while in summers excessively high temperatures do not occur because of the influence of breezes from the ocean The forest cover is heavy and the trees are long-lived. The forests are much like those of the more humid parts of the adjacent continental climates. In America, deciduous forests —consisting either of a chestnut, chestnut-oak, and poplar association, or, farther north, of an association of birch, beech, and maple—are prevalent on the lower and better lands. Pines are concentrated on the sandier soils, while at higher elevation spruce and fir appear Where forests have not been cleared, logging and lumbering are important. Another activity of economic importance in New England and New Brunswick is that of the gathering of maple sap for the manufacture of sugar and syrup, both famous products of the states and provinces concerned

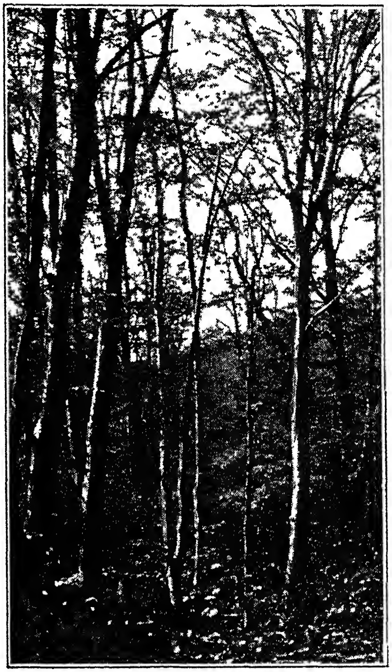


FIG. 242.—Mixed hardwood forest of southern New Hampshire.

In northern Japan, deciduous forests prevail—beech, maple, and oak being the principal trees The many different kinds of maple are especially responsible for the beautiful autumn landscape for which Japan is justly famous. In the mountains, coniferous forests are dominant

Soils.—In the warmer sections, from southern New England to Maryland, the gray-brownerths are the most common mature soils on the low uplands. They are productive when first tilled, and their structure is sufficiently stable to render them responsive to fertilizers on a basis of permanent crop agriculture The high productivity of truck and dairy farming as well as of small fruit culture in eastern Pennsylvania, New Jersey, and southern New England is due in no small degree to the quality of the soils of that section The economic returns are of course due to the great markets which these areas serve

In northern New England and the adjacent provinces of Canada, podsols are the prevalent mature upland soils They are weak soils, but fortunately the podsolic areas are well supplemented with younger alluvial soils Such immature soils are much more productive and serve successfully as a basis for the limited agriculture practiced there In Japan, gray-brownerths prevail in the south, podsols in northernmost Honshu, especially in Hokkaido.

Land utilization.—The use of the land is influenced to a great extent by the relatively low temperatures which prevail in many areas The growing season is as long as, or longer than, in the corresponding continental climates, but coolness and cloudiness are handicaps to the complete maturing of certain crops, in the northern sections especially In general, the summers are too cool for corn to mature, although some of the finest corn for human use (sugar corn from Maine) is grown in this climate Corn is produced also for fodder and silage In the northern part of this climatic region wheat will not ripen satisfactorily, but oats and rye, both of which are well adapted to cool and humid environments, are produced successfully Buckwheat is one of the principal crops in some sections. Potatoes, vegetables, and fruits are important phases of subsistence agri-

culture, and where markets are available they constitute major cash crops. Aroostook County, Maine, is famous for its potatoes, a crop so extensively and successfully raised that the state usually leads all others in its production of this commodity Cranberries are grown in such abundance that Massachusetts and New Jersey furnish the entire nation with most of its supplies of that fruit The ample rainfall, including winter snows, and the lack of extreme summer heat and winter cold are factors so favorable that New England and Nova Scotia have developed apple orcharding with marked success.

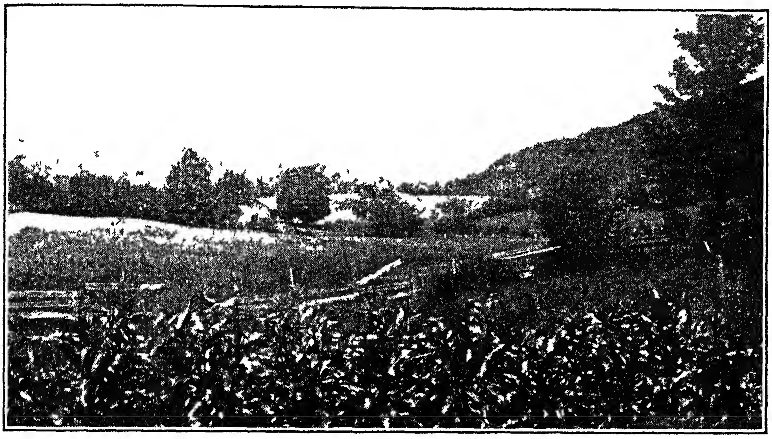


Photo by N A B

Fig. 243.—The Coolidge farmstead, Plymouth, Vermont Mixed farming in valley, higher slopes forest-covered.

The modified humid continental climate is one with sufficient changes of temperature to be bracing and invigorating It lacks the extremes of summer and winter which have proved too severe for many in the continental interiors, and there is no tiresome monotony of weather It is a climate that is friendly to man but, nevertheless, one wherein effort is necessary to physical well-being and economic success.

THE WEST COAST MARINE TYPE OF CLIMATE

Since the intermediate climates occur within the belt of the westerlies, there are marked differences between the east and

west coasts Along the eastern coasts the temperature extremes of the interior are modified to some extent by the adjacent oceans, but inasmuch as the prevailing wind direction is from the west, the influence of the continental interiors is still sharply felt To the west coasts, however, the westerlies bring oceanic instead of continental conditions, and hence the winters are mild and summer temperatures are moderate No season of the year is dry, but in general winter is the season of heaviest rainfall.

The regions in the Northern Hemisphere which have well developed marine climates are the west coasts of North America, from San Francisco to Alaska, and of Europe, from Portugal to Norway. Of course, conditions vary considerably from south to north through such a wide range of latitude, but moderate temperatures and abundant rainfall with winter maximum prevail throughout In the Southern Hemisphere this type of climate occurs in Chile, from Puerto Montt to Cape Horn, and in New Zealand Where lofty mountains occur near the coast —as in North America, Chile, and Norway—the marine conditions are strikingly developed in the narrow regions along the coast and on the lower mountain slopes In Europe, south of Norway, the lack of a high mountain barrier permits the oceanic influence to be carried far inland, but with diminishing effectiveness as the distance from the sea increases. Quite naturally, the rainfall is heavier and seasonal temperature extremes are less on the windward slopes of low mountain ranges, such as the Pennines of England, than they are on the leeward slopes.

Temperature.—The significant feature of this climate is the low temperature amplitude during the year, owing to the tempering influence of the westerly winds blowing from over the oceans The difference between the average temperatures of the warmest and coldest months does not exceed 36°F., and for a few places it is less than half of this. The average winter and summer temperatures are, of course, higher in the lower latitudes than they are farther poleward where this climate prevails For example, at Lisbon the average temperature of the warmest month is 70°F., of the coldest, 49°F.; at Cop-

enhagen the corresponding temperatures are 62°F and 49°F, respectively. In the higher latitudes where the marine climate occurs, the mild winter temperatures are the outstanding features Even far beyond the Arctic Circle in Norway the winters are so mild that the coastal waters remain unfrozen through the long winter months.

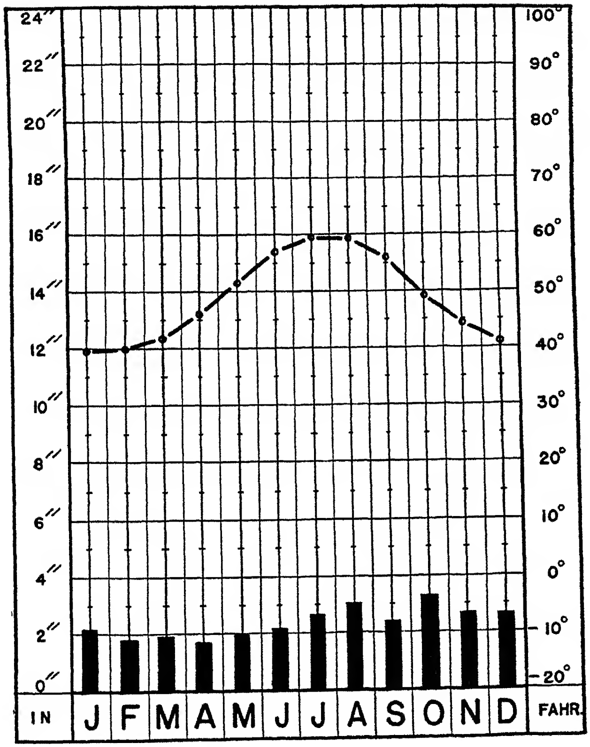


Fig. 244.—Marine west coast climate Average temperature and precipitation, Liverpool, England. Altitude 99 feet, total precipitation 28 inches.

Winds.—The weather is dominated entirely by the numerous low pressure areas which move in from the sea. The passing of these lows causes constant shifts of wind direction and windstrength, resulting in highly variable weather. Nevertheless, winds from westerly directions are by far the most frequent—from the southwest during the winter months, and from the west and northwest during the summer The stormiest condi-

tions prevail along the west coasts of Scotland and Norway and along the coast of southern Chile, the last named faces the highly developed westerlies of the Southern Hemisphere known as the "roaring forties"

The southwest and west winds bear the tempering influence of the sea across France and Germany into Poland and Russia, but, of course, with increasing distance their effects become less pronounced The transition from the equable marine conditions which prevail in southwest Ireland to the continental extremes of interior Russia is a gradual one, quite in contrast to the abrupt change one experiences in crossing the Scandinavian mountain ranges from Narvik, Norway, to Kiruna, Sweden.

Rainfall.—Rainfall varies with local conditions and with latitude Where there are rugged mountains near the coast—as in British Columbia, Washington, Norway, and Chile—copious rains bathe their western slopes, and in winter heavy snows fall on the upper slopes and highlands Some of the heaviest snowfalls known have been reported from the Cascades and the Canadian Rockies The Andes of southern Chile are rain-drenched and their upper valleys glacier-filled. At higher latitudes, however, as in Alaska and northern Norway, the total annual rainfall is lower, but the winter snows accumulate on the highlands and give rise to a snow-covered landscape that persists for many months of the year.

The oceanic type of rainfall is dominant along all the west coasts of these climatic regions. The rain does not fall in sudden heavy showers, but rainy weather may last for days, sometimes even for weeks The rainfall maximum occurs during the autumn and winter months, with spring and early summer the seasons of least rain. The periodicity, however, is not pronounced, and considerable rain falls in all months Cloudiness is common. In northern Scotland, for example, the period of unclouded sunlight averages less than an hour a day in winter All of northwest Europe has much cloudy and rainy weather, especially in the fall and early winter Sometimes the sun may not be seen for weeks, and umbrellas, raincoats, and overshoes

are always needed. These typically marine conditions of prevalent cloudiness and of a winter rainfall maximum change rapidly, however, with distance from the ocean. Central France, Germany, and southern Sweden have maximum rainfall in summer, and their skies are unclouded a much higher percentage of the time than is the case in Ireland or even southern England

The high humidity causes the winter cold to be sharp and piercing, even when the thermometer may stand well above the

Courtesy, U S Forest Service. Photo by E. T. Allen

Fig. 245.—Dense virgin stand of pure Douglas fir in Pierce County, Washington.

freezing point. In summer it often causes extremely muggy weather, then temperatures of 80°F. cause quite as much discomfort as do those of a hundred in the Great Plains of the United States

Native vegetation.—The mild west coast climatic regions have or have had heavy forest covers. Dense stands of timber, mostly firs, characterize the western mountain slopes from California to Alaska, one of the most heavily wooded regions in the middle latitudes and at present one of the world's principal centers of logging and lumbering The coast of southern Chile

likewise has a heavy stand of timber, but little exploited as yet. With the exception of the western part of the British Isles, where the strong west winds hamper tree growth and the high precipitation favors the development of moors, most of northwest Europe once was heavily forested with deciduous hardwoods and conifers, but of course the lands suitable for agriculture were cleared long ago and put into grass or tillage In England but little forest remains, and on the continent forests are limited mostly to the mountains and to very sandy areas. None of them are original stands Southern Norway has extensive stands of spruce and fir, but the northern part has few trees, because of long seasons with land temperatures slightly below freezing

Soils.—The agricultural soils of the mountainous areas which lie within this type of climate, particularly along the coasts of North America, Chile, and Norway, are limited to the valley lands. Their extent is relatively a small percentage of the total area involved These lands, which are wholly alluvial, vary so much in different localities that broad generalizations have little significance The soils are young, and where drainage is adequate and texture favorable to cultivation they are usually quite fertile.

Northwest Europe is the only region where a large percentage of the land is used for tillage agriculture. The mature soils are dominantly podsolic although areas of brownerths occur, as, for example, in eastern England Their structures are fairly stable, and crop yields are readily increased by the application of mineral fertilizers Among the best soils are those developed upon the alluvial deposits of the valleys and upon the recently emerged marine deposits along the coasts, as in the Netherlands and southern Sweden Glacial drift mantles much of the land which borders the North Sea, with soils varying in productiveness from the nearly sterile sands of parts of northern Germany to the fertile loams of eastern England and the Danish Islands. Farther south, non-glacial soils occur, varying in quality from medium to good. On the whole, however, the soils of northwest Europe are favorable to agricultural development, although

heavy application of fertilizer is necessary (See Fig. 82, fertilizer map.)

Land utilization.—In North America and Chile the forest is the principal asset of the regions which have the west coast marine type of climate. The valley lands of the Pacific Northwest are important centers for grazing, dairying, and truck farming, the Puget Sound-Willamette lowland being of foremost rank in this regard. Vancouver, Seattle, Tacoma, Portland, and adjacent smaller cities mark an urban district which gives rise to a profitable market, especially for such bulky or perishable products as cannot be shipped long distances

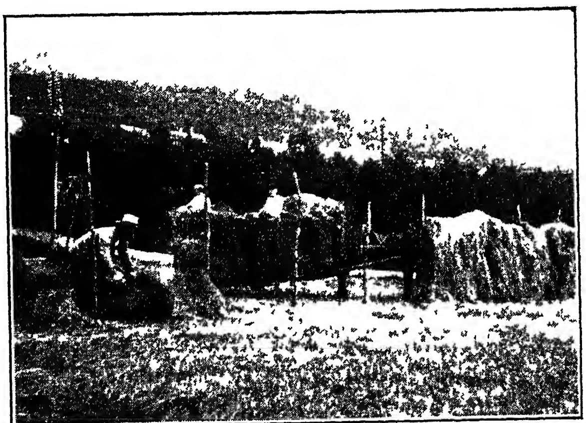


Photo by N. A B.

Fig. 246.—Haying scene near Narvik, Norway. On account of high humidity, newly mown grass must be hung over trellises in order to be cured into hay.

In Europe the region with a marine west coast climate shows considerable climatic diversity. In the south all seasons are comparatively warm and mild; in the north all seasons are cool, so cool that only the hardiest crops survive. In Scandinavia the change from marine to continental conditions is abrupt; in the lowlands of Germany it is gradual. The west coasts of Ireland and Great Britain are cloudy and rain-drenched, the east coasts have more sunshine and a moderate rainfall Under these conditions it is little wonder that agricultural diversity is pronounced. In southwestern France vineyards abound, while in

Norway only hardy grains such as rye and barley can be grown On account of high rainfall, oats is the principal grain in the western and northern parts of the British Isles, while wheat leads in eastern England and in France Potatoes constitute an important phase of crop agriculture in many parts of this region, especially in the Netherlands and Germany, the latter usually ranking foremost among all countries in amounts raised Poland also, although not wholly within this type of climate, is a great potato producing country The abundance of natural grasses and root crops, and the large markets furnished by the industrial centers which lie within this region, favor the development of the dairy industry. The renown of the Netherlands and Denmark as dairy countries rests upon the secure basis of a favorable natural environment, skillful operation by intelligent and industrious farmers, and proximity of markets which insure profitable outlets for the products

Viewed as a whole, regions having the west coast marine type of climate are lands of forest wealth, of agricultural diversity, and of industrial achievement Climatic conditions are sufficiently varied to be stimulating, but not so extreme as to be enervating.

THE SUBPOLAR TYPE OF CLIMATE

Poleward from the intermediate climates having long, cold winters and short, frost-free summers lies a belt of transition that practically coincides with the great belt of northern coniferous forests which girdles the Northern Hemisphere Beyond it there is no forest, but only shrublike vegetation The subpolar type of climate dominates northern Sweden and Finland, northern Russia, most of Siberia, central Alaska, and much of Canada. Within this belt a winter landscape of somber dark green and cold, dreary white is predominant for nearly nine months of the year, but during a brief summer period nature bursts into life with grasses and multicolored flowers which carpet the ground wherever the forest is not too dense to exclude them. Daylight is nearly continuous, and for a few weeks life surges through root and limb into leaf and flower Insects

and birds are then present in swarming numbers, enlivening the short summer season by their hum and song and busy activities.

Temperature.—While climatic conditions vary considerably within the subpolar regions, there are certain characteristics common to all. During the winter at least four months have average temperatures below freezing, while average tempera-

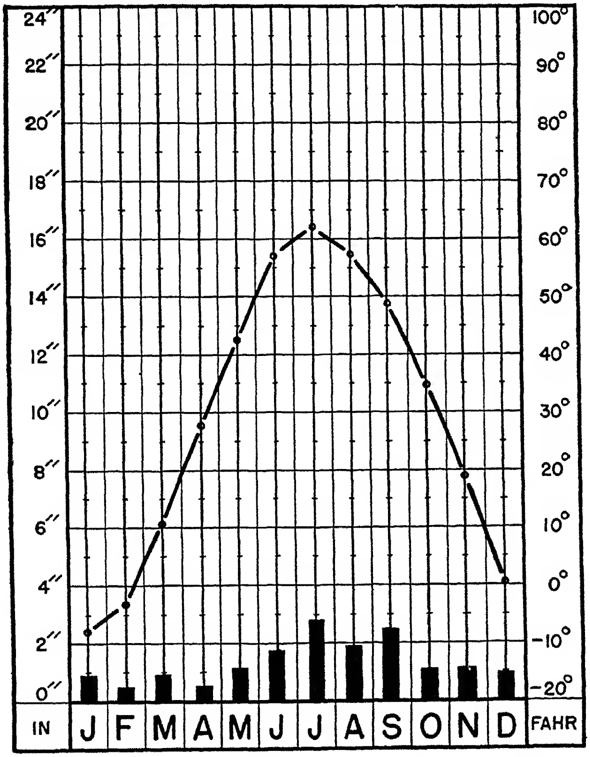


Fig. 247.—Subpolar climate. Annual temperature and precipitation, Fort Hope, northern Ontario, Canada. Altitude 1100 feet, total precipitation 16 inches.

tures of 50°F. or above are reached less than four months each year Even in the warmest season light frosts often occur at night, although day temperatures may be favorable for plant growth The native vegetation, therefore, consists of plants which are cold-tolerant and which are able to utilize a short and rather unsafe growing period Crops must be hardy, ripen-

ing quickly; in the far north, barley is the only crop which gives satisfactory yields The soil and subsoil are free of frost during the midsummer period, a factor of great importance to the development of the forests which prevail over most of the subpolar climatic regions The high annual range of temperature is another marked characteristic; the hottest summer days may

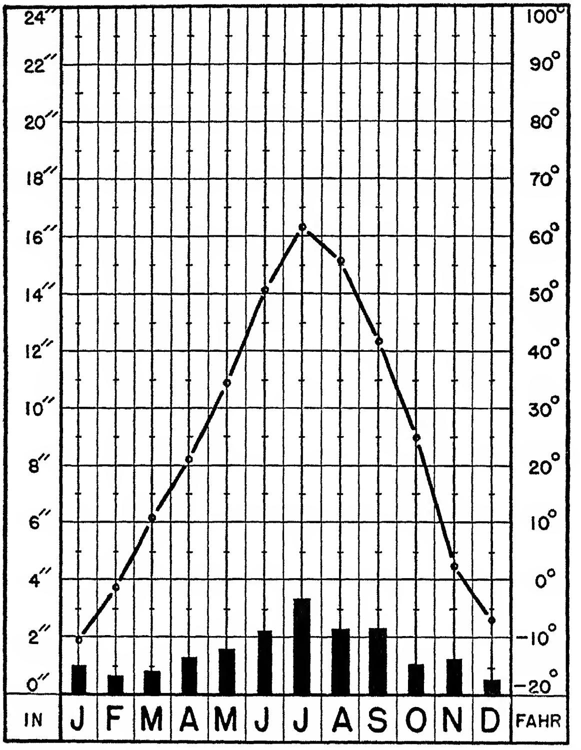


Fig. 248 —Subpolar climate Annual temperature and precipitation, Beresov, Siberia. Altitude 100 feet, total precipitation 18 inches.

exceed 90°F., whereas in the dead of winter the temperature may drop to -60°F, or even lower.

Winds and storms.—The regions of subpolar climate lie along the northern margin of the belt of prevailing westerlies. Where oceanic influences are somewhat effective and where cyclonic circulation is well developed—as over much of central Canada, northern Russia, and western Siberia—the winds are

subject to sharp, sudden changes, particularly in winter. While in most places travel is easiest in winter, because the bogs and rivers are then frozen and the land is snow covered, severe gales and accompanying low temperatures often render it hazardous.

Continentality of climatic conditions reaches its climax in Siberia, east of the Yenesei River. Pressure is abnormally high there during the winter, atmospheric disturbances are infrequent, and the air is calm; as a result, temperatures often fall below the freezing point of mercury, -39°F., but the dryness of the air and the absence of strong winds contribute toward making such temperatures bearable A distinct disadvantage, however, is the lightness of the snow cover, or even its absence ofttimes Summer temperatures, on the other hand, may be surprisingly high. At Verkhoyansk, the so-called "cold pole of the earth," temperatures above 90°F. have been registered

In central Canada temperature extremes are not so great as in Siberia, and the influence of the cyclonic storms is greater in summer than in winter because the cyclonic storms then follow northern courses, bringing with them into the higher latitudes air masses and water vapor from more southerly areas.

Humidity and rainfall.—Because of the low temperatures which prevail most of the time, the relative humidity is fairly high and the rate of evaporation is low The rainfall, however, is comparatively light, with a distinct summer maximum. Few places have an average of more than 20 inches per year. Since the summer season receives the benefit not only of the heavier rains which fall then, but also of the melting winter snows, the rainfall is sufficient for the needs of the vegetation which flourishes through the short season Where the growing period is less than three months long, precipitation of 15 inches is ample, whereas in lower latitudes semi-arid conditions would result The winter snowfall, even where light, accumulates so that for several months each year the landscape is white-blanketed, without interruption by warm spells such as produce the well-known thaws of more southern climes.

Native vegetation.—The regions of subpolar climates coincide roughly with the great belt of the northern coniferous for-

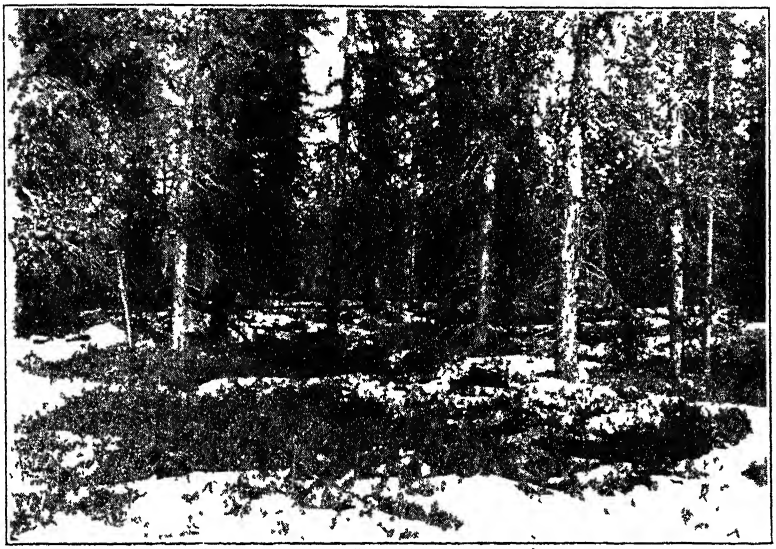
ests. Spruce, fir, and larch are the dominant species Only a few of the hardiest deciduous trees—such as birches, poplars, and willows—are found, and they only in sheltered places along stream courses or intrenched valleys. Growth is slow because of the temperatures which characterize the beginning and close of the growing season and because of the very short period wherein sunlight, warm air, and soil combine to favor plant growth.

Courtesy, Dr F J Lewis, Department of Botany, University of Alberta

FIG. 249.—Bog area in northern Alberta, near northern edge of coniferous forest.

Whereas the forest stand over the southerly portions of these regions in Canada and Eurasia is continuous and fairly heavy, toward the northern border it becomes scattered and scraggly as it approaches the limit of tree growth. Where local conditions are relatively favorable, a prong of forest projects northward; where they are unfavorable, only shrubs or a mixture of shrubs and stunted trees survive It is the margin of the coniferous forest where neither tree nor moss can claim supremacy. North of it is the treeless tundra; on the south it merges into the true coniferous forest, the *taiga*.

Soils.—The soils are podsolic A forest litter covers the upper horizon, and under it lies the well-known very light gray layer leached of its solvent minerals and organic matter The soils are, however, of but little significance, inasmuch as the climate is the direct factor which practically controls the type of human activities which may be practiced The agriculturally important soils are limited almost entirely to the immature alluvial lands bordering streams and lakes.



Courtesy, Dr F. J Lewis, Department of Botany, University of Alberta

Fig 250.—White Spruce forest of central Alberta in merchantable timber belt.

Land utilization.—On the whole, in the regions of subpolar climates man's cultural landscape has not made great inroads upon the natural landscape Such agriculture as is practiced is distinctly of the patch type and is almost wholly for local subsistence purposes. Barley, of the hardiest kind, is the chief cereal grown, although some rye is produced in a few districts along the southern margin Potatoes do quite well and serve as an important foodstuff in some areas, particularly northern Sweden, Finland, and Russia. Hardy vegetables and quick maturing berries play a local role.

The forest is the principal resource It has not yet been widely exploited in North America because other forested areas are closer to markets, but with their depletion will come increasing demands upon the resources farther north In Norway, Sweden, and Finland exploitation is being carried on profitably, coupled with a replanting program that has won wide acclaim. Russia has vast forest resources within the subpolar climatic region, and while some use is being made of them, their full exploitation must await the establishment of better facilities for transportation than are now available

The northern coniferous forest to date has been of less economic importance for its trees than for its furs The fur-bearing animals of Canada, Alaska, and Siberia have long provided the essential raw materials for the world's finest fur coats and scarfs The activities of hunting, trapping, trading, and transportation serve as the basis of existence for some of the oldest and best known corporations in the world, among which the Hudson Bay Company is conceded premier position in North America

On the whole, the subpolar regions are characterized by such climatic hardships that they must be classified as unfavorable to human progress They contain resources of vast possibilities, but exploitation awaits demands from without these regions. Their fur resources have long been exploited successfully, but markets have been and are now almost entirely where climatic conditions are less severe The forests will become important in the near future as sources of pulpwood and structural timber for the lands to the south Exploitation of mineral wealth will probably progress along similar lines Valuable as these regions are to the rest of the world, they will never be the seat of dense populations nor the centers of great cultural achievement. The winters are too long and too cold!

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CHAPTER XXIII

The Dry Intermediate Climates

SINCE the middle latitudes are dominated by the prevailing westerlies, the dry lands are found only east of high mountain ranges or far inland outside the paths of the cyclonic storms. The former is the case in North and South America, the latter in Eurasia east of the Black Sea. These dry intermediate climates may be divided into two main types: the semi-arid, or steppe, and the arid, or desert type.

The middle latitude steppes and deserts generally have greater annual range of temperature than do the neighboring regions of humid climates; summers are hotter and winters colder The diurnal range also is relatively great; the days are warmer and nights colder than in the humid regions, and the passing of occasional lows may bring sudden and violent changes in temperature.

Inasmuch as these climates occur where the average annual temperatures are considerably lower than in the dry tropical regions, evaporation is less rapid and whatever precipitation falls is more effective In general, the average annual rainfall in the semi-arid intermediate regions is below 20 inches, and that of the deserts is less than 10 inches The true deserts, those virtually devoid of vegetation, however, have less than six inches of rainfall yearly. In both the deserts and the steppes the rainfall varies greatly from year to year. This variability, particularly in the steppes, is often attended by serious economic consequences.

Although trees are generally lacking in the semi-arid lands, except along the larger watercourses, the rainfall is sufficient to maintain a fairly continuous vegetative cover consisting of short grass and xerophytic bush This vegetation can support

grazing, and where rainfall is greatest some of the land can be used successfully for crop agriculture While none of the deserts, except the Takla Makan of Chinese Turkestan, exhibit conditions of such extreme aridity as are found in the Atacama or in parts of the Sahara, the vegetation is so sparse that the land can be used only for extensive forms of nomadic pastoral pursuits

THE INTERMEDIATE SEMI-ARID TYPE OF CLIMATE

The most prominent semi-arid regions in North America are: (1) the Columbia Plateau, lying between the northern Rockies and the Cascades; and (2) the Great Plains, extending from southern Texas well into Canada along the eastern front of the Rocky Mountains These, however, are exceeded in extent by the steppes which extend from southern Russia far into the interior of Asia The corresponding region of steppes in the Southern Hemisphere lies along the eastern base of the Andes in Argentina Australia and Africa have semi-arid lands, but because of their prevalently high temperatures they more nearly resemble the semi-arid lands of the low than of the middle latitudes.

Temperature.—Temperature conditions vary widely with latitude and to some extent with altitude Monthly temperatures range from 12°F. in January in the northern Great Plains to 44°F. in the southern part, and from 61°F in July in the north to 82°F. in the south. The average summer temperatures, June to August inclusive, vary from 80°F in Texas to 60°F in southern Canada, while the winter temperatures, December to February inclusive, vary from 50°F in Texas to 10° or 15°F. in southern Canada. In general, the average length of the frost-free season is not less than eight months in the warmest portions, while in the colder areas it is but three to four months

Winds.—Although these semi-arid regions lie in the belt of the prevailing westerlies, local weather conditions vary widely In North America the westerlies bring moderate rainfall to the Columbia Plateau during the winter season, but east of the Rocky Mountains they are accompanied by little moisture un-

til after they have crossed the Great Plains In summer when the storm paths are farther north than in winter, the vapor-bearing cyclonic winds from the Gulf of Mexico penetrate far inland and bring to the Great Plains the major share of their annual rainfall.

In southern Russia and Siberia northeasterly winds from the

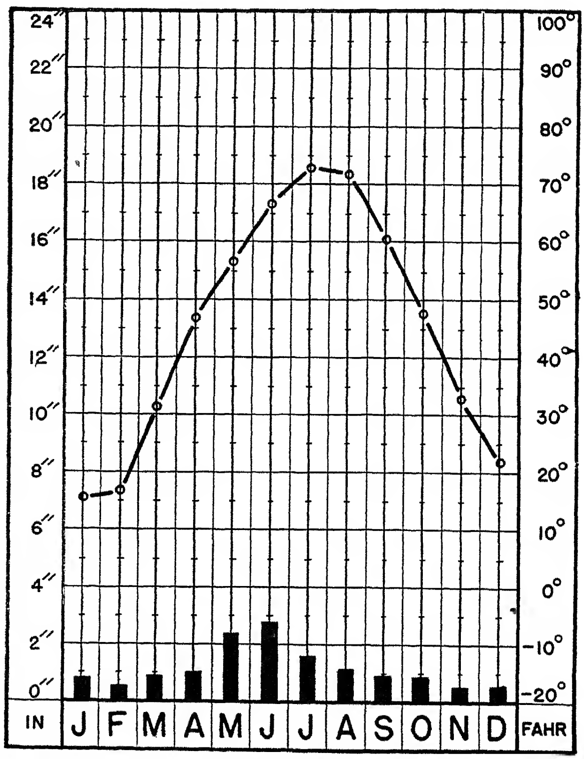

Fig 251 —Middle latitude steppe climate Average temperature and precipitation, Miles City, Montana. Total precipitation 13.5 inches.

Asiatic high pressure area prevail in winter, while during the summer the winds generally are from a northwesterly direction. During both seasons the effects of cyclonic storms passing to the northwest are occasionally felt. In the steppes of Mongolia the influence of the Asiatic monsoons predominates

Wind velocities in nearly all semi-arid plains are relatively high In the northern Great Plains of the United States and

Humidity and rainfall.—Although the average annual precipitation varies from 6 to 20 inches in regions having semi-arid climates, these limits are by no means exact. In the middle latitudes the semi-arid regions of both the Americas have a wide extent north and south Hence, differences in temperature, in the length of the growing season, and in the intensity of evaporation are so great that rainfall alone does not determine the degree of aridity. In southwestern Texas, for example, the evaporation factor during the long warm season is about twice as potent as it is in the shorter warm season of the northern part of the Great Plains; this difference has been estimated by Kincer [1] to have an agricultural significance of having about 10 inches of rainfall in excess of 20 inches annually and still remaining semi-arid, while the cooler sections may not be semi-arid even though the annual rainfall is below 20 inches

In semi-arid regions the agricultural significance of the rainfall depends chiefly on seasonal distribution, seasonal and yearly variability, and the rate of evaporation. In North America the cooler areas, in addition to being favored by a lower rate of evaporation, have the advantage of a highly favorable seasonal distribution of rainfall. This is particularly true of the Great Plains At Calgary, Canada, 73 per cent of the annual rainfall occurs during the months May to September, compared with 61 per cent at Abilene, Texas. On the Columbia Plateau the season of maximum rainfall occurs from November to February, inclusive, when about 50 per cent of the total may be expected

Variability of rainfall is perhaps the most critical climatic factor in semi-arid regions Some years may have 50 per cent or more above the normal, while others may drop as much below; such variability is of much greater economic significance where the average is near the lower limit of tolerance for crop plants than where the average is relatively high. There seems to be a tendency for comparatively wet and dry years to occur

[1] Kincer, Joseph B · "Climate of the Great Plains as a Factor in Their Utilization," *Annals of Association of American Geographers,* Volume XII (1922), p 73

in groups, but without any dependable regularity. Furthermore, in the Great Plains particularly, rainfall is below normal in more than half the years. In the same place the rainfall may range from a sufficiency to maintain humid agriculture to an amount hardly able to support scattered bush vegetation. This variability is a factor that should be considered normal and typical for most of the semi-arid lands of the world Agricul-

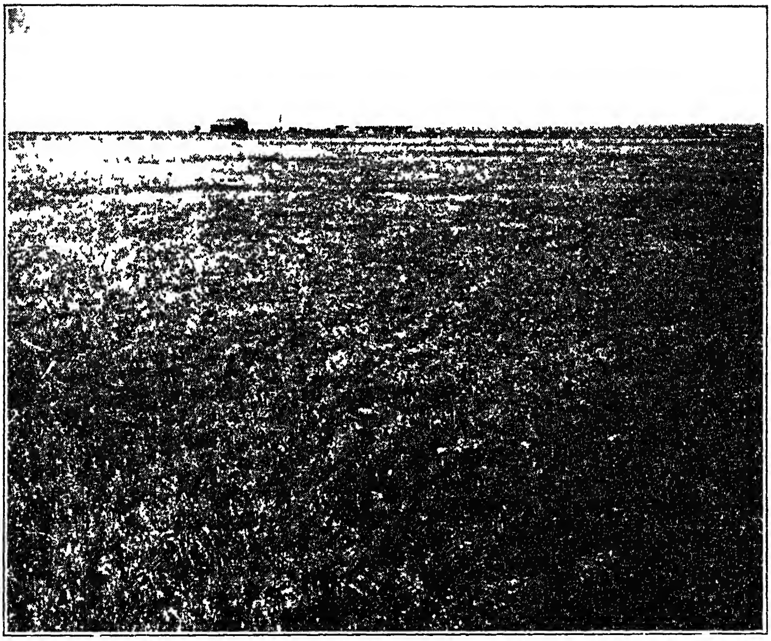

Photo by J E Weaver, University of Nebraska

Fig. 252.—Short grass steppe of eastern Colorado.

tural and pastoral activities should be planned and practiced accordingly. Then, during wet years preparation should be made for the drier years which may be expected to follow. There is no evidence at hand to indicate that any permanent climatic changes are now occurring.

Native vegetation.—Regions of semi-arid climates are characterized by comparative sparseness of vegetation, but the cover is practically continuous and thus contrasts with deserts, where it is patchy or entirely absent. There are three major

groups of native flora, all of them of the low growing type; trees are found only along water courses. In the humid sections where the rainfall is sufficient to cause relatively deep penetration of moisture, tall grasses abound. This type of vegetation is transitional between the humid and the semi-arid climatic areas, and thus is found within both In the Great Plains of the United States the tall grass vegetation occurs in both the eastern and northern portions, in the former because of the greater rainfall which characterizes that section, and in the latter because of the greater efficiency of the precipitation, resulting from a lower rate of evaporation The tall grass vegetation in the United States and Canada merges westward, and in Russia southward, into the short grass type which to most people represents the typical steppe Where the rainfall is too low to support grass, and where temperatures are relatively cool, sage brush is likely to predominate. This type of natural vegetation prevails in the drier sections of Montana and Wyoming as well as on the Columbia Plateau, where it is dominant over large areas In the southern part of the Great Plains, in New Mexico and southern Texas, mesquite and thorny bush interspersed with some grassy areas are the major phases of the vegetative cover. Although rainfall is about the same in the south as in the north, its efficiency is less because of the longer growing season and the higher rate of evaporation; consequently the vegetation approaches more nearly the desert type.

Soils.—The mature soils of regions having the semi-arid type of climate belong to the pedocals. They are dark in color and have a zone of alkaline salt accumulation, usually, although not exclusively, of lime carbonate The color is generally dark brown in the more humid sections and lighter brown where rainfall is lower Furthermore they are darker colored in the cooler portions than they are in warmer areas

The soils of the eastern Great Plains of North America are blackerths, located in the transition belt from humid to semi-arid climatic conditions They correspond to the chernozems of the steppes of European and Asiatic Russia, which occur there under similar climatic conditions. They are darker than the

true semi-arid soils, and the zone of lime accumulation occurs at greater depths, usually from two to five feet below the surface The dark-colored horizon is from 10 to 24 inches in thickness and has a stable granular structure The blackerths are among the aristocrats of soils, productive without the use of fertilizers, rich in humus, readily tilled, and highly productive Given a sufficiency of moisture, they will give abundant yields of any crops suitable to the growing season and other climatic conditions of the locality involved.

Where rainfall is less than in the blackerth areas the soils are shallower, lighter in color, and the lime-accumulation zone is nearer the surface These soils have been classified as brownerths,[2] a term aptly descriptive of their general color These soils have been developed under a grass cover which, because of lower rainfall, was of lighter growth and had a shallower root system than the tall grasses which dominate the blackerth areas. The lime accumulation zone occurs from six or eight inches to two feet below the surface.

In areas approaching desert conditions, where rainfall is too low to support continuous grass cover, the soils belong to a group known as the *grayerths*. These are the principal soils in the Great Basin and Colorado Plateau regions of the United States. The color varies from light brownish gray in the north to almost reddish in the south The surface horizon is a thin pebbly layer, and under it is a zone of light porous material. The subsoil is usually brown and compact. The zone of lime accumulation is near the surface and is often firmly cemented into a mineral hardpan. The grayerths are necessarily low in humus because of the paucity of vegetation which can be supported by the meagre rainfall.

On the whole the soils of the semi-arid lands are readily tilled and are productive where water is available Crops yield abundantly under irrigation, or without irrigation in years when rainfall is above normal. The unleached soils contain an

[2] Marbut, C. F · "Soils of the Great Plains," *Annals of Association of American Geographers,* Volume XIII (1923), p 58

abundance of soluble mineral salts Since under natural conditions these salts are usually well disseminated throughout the soil, they do not impair productivity. However, when irrigation water is applied, care must be taken to provide adequate drainage or else the alkali salts will be concentrated near the surface of the soil by the evaporation of excess moisture Such concentration causes good lands to become "alkali" and thus almost worthless for crop production. Costly errors involving disastrous consequences have been made in some of the irriga-

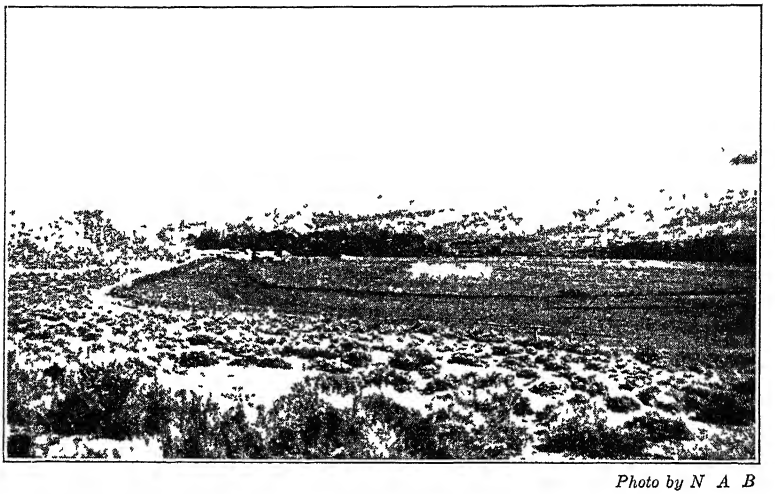

Photo by N A B

FIG. 253.—Sage brush vegetation in the western Great Plains. Irrigated valley, Dubois, Wyoming.

tion projects by failure to recognize the danger of concentration of alkali salts

Land utilization.—Semi-arid lands nearly everywhere mark the transition from crop farming to cattle along their humid margins and from cattle to sheep in their drier portions During wet periods crop farming may become so profitable that it encroaches seriously upon grazing lands, only to be forced to retreat again upon the inevitable return of dry years

The semi-arid regions are important in wheat production, autumn-sown varieties being dominant in the warmer sections and spring wheat in the areas where the winters are severe. The

semi-arid lands of Russia, Canada, and the United States include some of the greatest hard wheat producing regions of the world The wheat lands are located in the more humid portions, where the accumulated winter moisture is augmented by sufficient spring and early summer rainfall to make a wheat crop before the heat and summer drought become severe The best wheat lands are in the blackerth areas, where the sufficiency of moisture was early indicated by the tall grass prairie Wheat is produced also in the drier brownerth and short grass areas, but yields are less dependable and such lands are therefore more definitely marginal than are the blackerth dis-

Photo by N. A B.

Fig. 254.—Wheat farming in the short grass steppe of western Nebraska. Shows strips of fallow land alternating with strips of growing wheat.

tricts. The wheat crops which ordinarily place Kansas, North Dakota, and Nebraska at the head of the procession in the United States are produced chiefly in the subhumid and semi-arid portions of the Great Plains

Cattle grazing is important in all semi-arid regions, the intensity depending upon vegetation and the marketing facilities Forage crops are produced to supplement the natural pasture wherever pressure of population is such that the land can profitably be used to nearly its full capacity Drought-tolerant forage crops, such as millets and sorghums, have been brought from Eurasia and introduced into the Great Plains with con-

spicuous success The open range which formerly characterized the semi-arid lands of the United States has given place generally to fenced ranches wherein pasturage of the native grasses is controlled more or less efficiently and is supplemented by fodder crops and, in some cases, by yard feeding This change has nearly eliminated the cowboy as the picturesque character of earlier days. The "cow country" has been pushed into the drier regions of the southwest, and but few of its original characteristics are now found within the Great Plains In Patagonia the cowboy, called the *gaucho,* is still a picturesque figure, but even there he is gradually being shoved westward by the

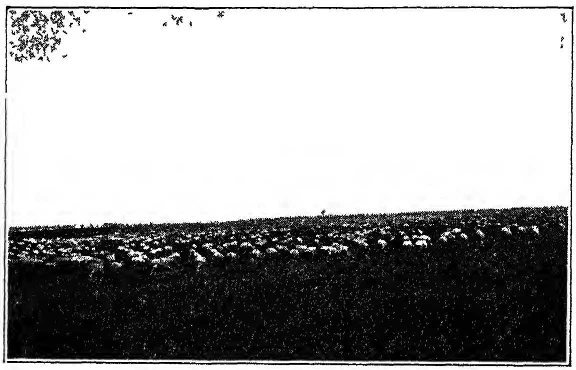

Photo by N. A B

Fig. 255.—Sheep grazing on the short grass steppe, the Pierre plains near Ardmore, South Dakota.

encroachment of crop farming and fenced ranching. It seems certain that in Argentina, as in the United States, the activities of the cowboy will be confined to lands where rainfall will not support grain production but where it is sufficient to maintain a grass cover.

Sheep ranching predominates in the drier sections where sparseness of vegetation is due to low rainfall, high evaporation, or poor moisture retentiveness of the soil It is an industry that may be considered transitional between the semi-arid and the arid lands There sheep are raised wherever forage is such that cattle do not prosper but where sheep do well. Under even more unfavorable conditions some profits may still be made

with goats. The livestock situation may thus be summarized by stating that the fat grazing lands are used for cattle, the sparse grazing lands for sheep, and the lands characterized by bush and hardy shrub, which are too lean for sheep, may provide forage for goats

Where water is available and markets are accessible, extensive irrigation systems have been constructed, particularly in the United States East of the Rockies, large projects are in operation from Montana to New Mexico. The greatest degree of success has been achieved in the northern half of the Great Plains, because of the larger size of the rivers which head in the mountains and flow across that section Similar projects have been developed on the Columbia Plateau High yields per acre may readily be obtained under irrigation, because generally the soils of semi-arid regions are exceptionally fertile and the alluvial lands are easily tilled. The crops which have proved most successful belong to one of two types, either those which need abundant moisture with much sunshine and give large cash returns per acre, or those for which local demands are comparatively strong Sugar beets, melons, specialized fruits, and early season vegetables are examples of the former, while illustrative of the latter is the more extensive type of agriculture—namely, that of producing feed and forage to supply the local markets provided by the grazing industry. Since the areas under irrigation are small in comparison with the unirrigated uplands, the needs of the ranches for feeds to supplement the ranges, especially in winter, are such that comparatively high prices are usually paid for the forage and grain crops produced in the valleys under irrigation Furthermore, the ranchers of the Great Plains find it advantageous to finish, so far as possible, beef cattle for the market prior to sale, and for such purposes quantities of alfalfa, sorghums, and grains are demanded.

The combination of factors referred to—namely, the production of specialized crops such as sugar beets, and the production of feed crops for local markets—has given great impetus to the development of irrigation projects in the semi-arid regions of the United States. This development has not been equalled in

any other semi-arid area of the middle latitudes Furthermore, the belief that the national welfare of the entire country would be enhanced by making the slightly productive areas more productive, and thus adding to the national income and to national strength, has been an important factor in promoting this development.

The outlook.—When the question "To what purposes should the land be put?" is faced, no climatic regions demand more careful study than do those of the semi-arid type Sound policies of land utilization must be based upon a knowledge and consideration of many factors. The topographic features, the quality of the soil, the native vegetation, length of growing season, severity of winters, the heat of summers, the amount, seasonal distribution, and annual variability of rainfall—all are factors of major importance Economic returns depend upon the selection of such crops as are adapted to the existing natural conditions For cultivated crops, methods of tillage to conserve moisture must be employed The ability of the soil to withstand wind action and the erosive effect of dashing rains should be carefully studied before the native vegetation is disturbed The economic factors should be given careful consideration. Crop production should be favored only where profitable returns may be reasonably certain on a basis of average or even below average conditions, and should be discouraged in all sections where such returns can be expected only under the most favorable weather and market conditions Large areas of semi-arid lands still await exploitation in Asia, South America, and Canada, as do smaller areas in the United States Careful surveys should be undertaken before the sod is disturbed in such places

Rather extensive areas in the northern and central Great Plains have already been denuded of their native vegetation, and we now face the problem of reclaiming them The natural reëstablishment of the native sod is a slow process; nature must be aided by man if early return to productivity is desired Lands with soils too light to withstand wind action in dry years should be withdrawn from agricultural use, and every possible effort

should be made to reestablish the grass cover It is to be hoped that the mistakes of the past, wherein during wet years lands were broken and put into tillage regardless of soil conditions, may not be repeated In the future, when several wet years follow one another in succession, as they may be expected to do, let owners and users beware lest they extend the cultivated acreage into areas where only grass can be permanently successful. Grass is nature's adaptation of arid land to the climate Man should study carefully all the factors and the probable results before he destroys the sod.

THE INTERMEDIATE ARID TYPE OF CLIMATE

The deserts of the middle latitudes, as a class, are not so completely desolate as are those of the low latitudes In the latter, temperatures are high throughout the year, humidity is low, and the intensity of evaporation is great, whereas in the middle latitudes the cold season includes several months of the year during which time evaporation takes place slowly Furthermore, the average annual rainfall is slightly greater in most of the middle latitude deserts than in those of the low latitudes As a result of the somewhat larger amount of rainfall and its greater efficiency in providing soil moisture, the scattered xerophytic vegetation is more abundant in the cool than in the warm deserts

The middle latitude deserts which are best known are in southwestern United States and in central Asia. The deserts of the Great Basin and the Mohave of California are examples of the former, and Takla Makan and Gobi of the latter All are interior basins practically surrounded by mountains which prevent the inflow of vapor-laden winds.

Climatic Conditions.—The climatic conditions may be summarized in a few broad general statements The average annual rainfall is less than 6 inches in most places although some areas have up to 10 inches. Diurnal and seasonal ranges of temperature are pronounced; the maxima in summers are comparatively high and the minima of winter are low. Days in summer may be hot and nights cool Winds are strong and ir-

regular Freezing temperatures at night persist later in the spring and begin earlier in the fall than is generally the case in humid climates of the same latitude and altitude. Since, however, deficiency of rainfall is the one dominating cause of low productivity of the land, the other factors are of little significance

Desert soils are generally gray and of coarse texture. Sharp changes of temperature cause disintegration of the rock by mechanical processes which result in gravels and sands. Chemical

Courtesy, Desert Laboratory of the Carnegie Institution, Tucson, Arizona

Fig 256 —Desert vegetation in Arizona Note large cacti and wide spacing of brush.

processes are retarded by coolness and dryness, and so decomposition proceeds slowly Soils which develop under these conditions are gray and somewhat stony. Low rainfall causes but little leaching, and, since much of the soak-in returns to the air by surface evaporation, the dissolved mineral salts are not carried away but are left in the upper part of the soil. Desert soils are rich in soluble alkali minerals, sometimes so rich that plant growth is impossible, but they are low in humus because of the scantiness of the vegetative covering.

Vegetation.—Cacti, thorny bush, and "cat's claw" vines typify the plant life of the desert. Where winters are severe most of the above-ground structures die down, a condition quite in contrast to the warm deserts, where perennial cacti often grow to tree size and in some places into forest deneness.

Land utilization.—Middle latitude deserts are grazing grounds of extremely low carrying capacity. Cattle can be grazed only where supplemental feed is provided by mountain pastures or by irrigated agriculture. Sheep ranching is the most widespread phase of land utilization in the arid lands, this be-

Courtesy, American Museum of Natural History *Photo by Roy Chapman Andrews*

Fig. 257.—A herd of goats near the edge of the Mongolian desert.

ing notably true both in the United States and in Argentina But even this industry depends in no small measure upon pasture lands in the adjacent mountains or upon supplemental forage produced under irrigation

In arid lands of the middle latitudes as in those of the low latitudes, where other forms of livestock fail, the goat persists. While in the New World the pressure upon the land has not forced maximum utilization of desert wastes to the extent that it has in the Old World, and therefore the goat has not become so common, goat raising is an industry of considerable importance in southwestern Texas, New Mexico, and some other areas

of near-desert conditions. The goat is the last word in land utilization; where ruggedness or drought stops him, man can hardly expect to succeed. When, in America, pressure upon the land becomes much greater than at present, we may expect economic conditions to make goat raising in the desert wastes of the Southwest increasingly profitable.

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CHAPTER XXIV

The Principal Agricultural Industries in the Intermediate Regions

AGRICULTURE in the extra-tropical regions, and particularly in those of the intermediate climates, is essentially dissimilar from that in the tropics Its aims and methods are different, it produces different crops, and it must meet different problems.

In the tropics agriculture for sustenance purposes prevails, and commercial agriculture is carried on mostly in the form of large scale capitalistic enterprises under western management In the temperate regions, though many farmers still produce primarily for their own immediate needs, commercial production is of much greater importance and is generally carried on as relatively small scale individual enterprises

In the tropics the land can produce throughout the year, but production in the areas of intermediate climates is limited by the occurrence of a cold season during which temperatures are unfavorable for plant life Shorter growing seasons and lower average temperatures make it necessary to grow crops which are hardier than those raised in the tropics Thus there is, on the whole, little overlapping in the types of crops produced by the two major agricultural belts of the world, the tropics and the middle latitudes. Where the former grow rice, cassava, and sorghums as the major foodstuffs, the latter produce wheat and rye Only corn, essentially a crop of intermediate and subtropical climates, has in the course of the last centuries become an important food and feed in many tropical districts

While the animal industries are of secondary importance in the regions of warm climates, they play a vital role in the intermediate regions, producing enormous quantities of raw ma-

terials for industry, of meats and animal fats. The tropics, on the other hand, are much larger producers of vegetable fats, many of which are indispensable to modern industry. Relatively few products are common to both the tropics and the middle latitudes, the principal ones being sugar and tobacco. Although tropical sugar does compete with sugar produced from beets, and could do so even more successfully if no tariff restrictions existed, many of the tropical tobaccos, because of their unique aroma, cannot be considered competitive with those raised in the intermediate climates. Tropical fruits likewise are largely non-competitive because their qualities differ so materially from those grown elsewhere Thus, the products of tropical and middle latitude agriculture are so diverse that they give rise to an extensive commercial interchange, a trade necessary to the welfare of the people of both of these climatic zones, and one which will undoubtedly tend to increase in volume.

Among the numerous non-industrial products of the middle latitudes, only those can be discussed which are of great importance from a world point of view and which enter international trade in relatively large quantities In the regions of intermediate climate commercial production of fruits, such as apples and berries, considerably exceeds similar production in the tropics and subtropics, but in comparison with the other products of agriculture their importance is so small that they cannot be included in the following discussion.

WHEAT

The most important food of the inhabitants of the middle latitude and dry subtropical regions is and has always been some form of bread. Archeologists, searching for relics of human occupation and human life in the ages that preceded the period for which we possess definite historical records, have often found caches of grain, and sometimes even evidence of breadmaking In the book of Genesis man is ordered to earn his own bread, and the principal prayer of Christianity includes a reference to this all-important staple food.

Wheat is the best bread-making grain, and thus wherever man was settled in the intermediate and dry subtropical regions he has planted it From ancient times it has been a staple crop on which not only the life of individuals but often even the stability of states depended

Climatic adaptability of wheat.—The wide geographic distribution of wheat, from British India to southern Finland, and from central Texas to the Peace River, was made possible by its adaptability to various climates. This adaptability is largely a result of the fact that botanically the genus wheat (Triticum) consists of several species, most of which have developed numerous varieties, adapted to various sets of environmental conditions.[1]

The planting season—winter and spring wheats.—The common distinction between spring and winter wheat refers only to the time of planting and does not necessarily indicate a difference in species By slow adaptation spring wheats may be changed into winter types and vice versa. A wheat which is fall-sown on the plains of northern India, where mild winters prevail, might have to be sown in the spring on the plains of Nebraska and Kansas, where the winters are rather severe In some countries it is difficult to distinguish clearly between fall and spring varieties. In northern Africa the sowing season lasts well into January, while in southern Argentina it does not end until the first half of August, in the spring and not in the fall If the winters are of such severity that the wheat plant is frequently subject to winter killing, the sowing generally is done in the spring. This is the case where average winter temperatures are low, where periods of freezing and thawing alternate, and where snow cover is light or wanting

The extreme limits of wheat cultivation.—Notwithstanding its great adaptability, wheat cannot be grown in some extensive areas because of adverse climatic conditions. Where winters are long and severe and summers cool, with growing seasons of

[1] Among the principal species of wheat should be mentioned common wheat (Triticum vulgare), club wheat (T compactum), spelt (T spelta), durum wheat (T durum), rivet or cone wheat (T turgidum), Polish wheat (T polonicum), and emmer (T dicoccum)

less than 100 days, little wheat is produced. It is virtually absent in the regions with a subpolar type of climate; in North America and Eurasia these regions approximate the broad belt of northern coniferous forests.

Equatorward the limiting factor is essentially a combination of temperature and humidity It is not altogether impossible to grow wheat under tropical conditions, but the plant becomes so susceptible to diseases that such a possibility is only of academic interest. Practically speaking, wheat is not produced in regions of tropical climates. The warm limits however, vary considerably from place to place In humid subtropical regions, as in southern China and southern United States, wheat is of little importance. In the dry subtropical regions, however, wheat is the principal grain. There it is sown during the late fall and early winter. It matures during the late spring and is harvested in the early part of the dry summer. Under such favorable climatic conditions wheat is grown in rather low latitudes in French North Africa, in Egypt, and in Palestine On the dry western part of the Deccan Plateau of British India, where a tropical savanna climate prevails, the cultivation of wheat extends to within 15 degrees of the equator. This, however, is an exceptional case; nowhere else within the tropics is wheat grown extensively.

Soil requirements.—Wheat prefers fertile loamy soils, especially those which contain a certain amount of lime. On the stony glacial soils of New England, where corn gives satisfactory yields, wheat has never done well except during the first few years of cultivation. Although in this case climatic and soil factors are difficult to separate, the latter undoubtedly strongly affect yields On the well drained, fertile marine clay silts of the Netherlands and northwestern Germany wheat is successfully grown, but on the adjoining sandy glacial soils it cannot be economically raised even for local consumption

Moisture requirements.—The optimum precipitation for wheat seems to be somewhere around 25 inches per year, varying, of course, with seasonal distribution and with average temperatures. Even where temperatures are relatively moderate,

excess of moisture has a decidedly unfavorable effect. Thus, little wheat is grown in the rainy coastal sections of Oregon, Washington, and British Columbia, in Ireland, and in western England On the other hand, it thrives where precipitation is considerably below the optimum, and under such conditions it seems to do better than most other crops.

Wheat as a subhumid and semi-arid crop.—As a result of this ability to flourish where corn and other grains do not give satisfactory yields on account of lack of moisture, in many parts of the world the cultivation of wheat has been pushed into subhumid lands. An additional reason is that under conditions of

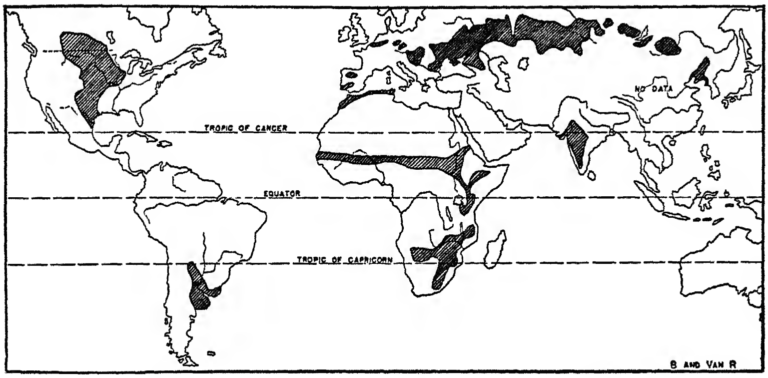
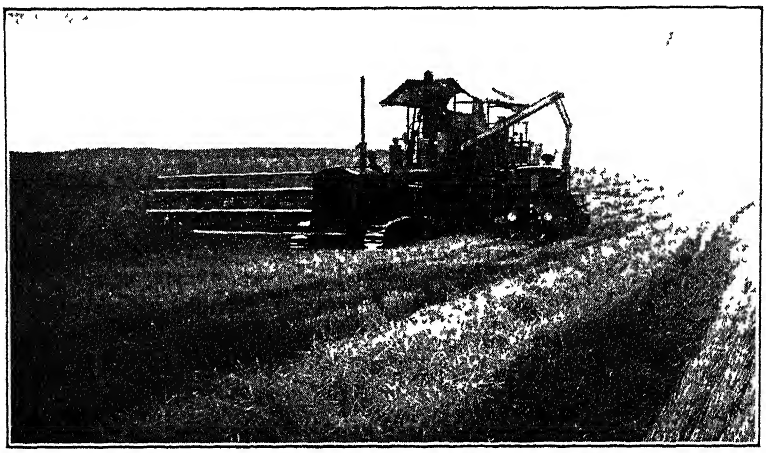


Fig. 258.—Principal black soil and related soil areas in the world. After Hollstein, Marbut, Wolfanger, Glinka, Prassolov, and others.

extensive agriculture, such as prevail in the United States and southeastern Europe, a crop like corn tends to yield more heavily than wheat, even where the rainfall is near the optimum for the latter crop.

The subhumid to semi-arid lands of the middle latitudes had an original stand of grass. The scarcity of water and lumber on these grasslands long formed obstacles to their agricultural utilization. They are, however, very fertile, because the low rainfall prevented the loss of much valuable plant food, even that of lime, through leaching, while the age-long grass cover has enriched the soils with humus materials that impart to most of them a rather dark color.

Colonization of the temperate grasslands.—In Russia the settlement of the woodland steppe and of the steppe proper proceeded slowly during the eighteenth and nineteenth centuries. Likewise, in other parts of the world the farmers, accustomed to an agriculture developed in forest regions, long regarded these grasslands as unfit for anything but the cattle industry. Tillage agriculture did not become practical on the subhumid grasslands until the latter part of the nineteenth century. Then, with the aid of modern agricultural machinery and well drilling equipment, and with the facilities offered by rail-



Courtesy, Omaha Chamber of Commerce

Fig. 259 —Wheat harvest on the High Plains, near Oshkosh, Nebraska The use of the combine enables farmers to cut and thresh the wheat in one operation.

road transportation, extensive farming became profitable on large areas formerly deemed unfit for tillage Wheat was the staple crop which gave the quickest returns on the heavy initial expenses of colonization Thus, within a brief period the subhumid and semi-arid lands outside the tropics became not only large producers of wheat, but also the chief exporters As a repercussion to this revolutionary development in world agriculture, the acreage of wheat began to decline in western and southern Europe and in the United States east of Chicago This decline is still making itself felt, although in many coun-

tries government protection of the wheat industry has tended to retard this downward trend, or even to reverse it.

Principal wheat producing regions.—Even with the limitations imposed by climate, soil, economic, and social conditions, wheat is grown widely in the intermediate and subtropical regions, for both subsistence and commercial purposes Among the important producing countries there are several in which large quantities are produced for the home markets and where the crop has only an indirect influence upon world trade and world prices. Among these should be mentioned France, Italy, Spain, China, and Germany Both France and Italy rank as

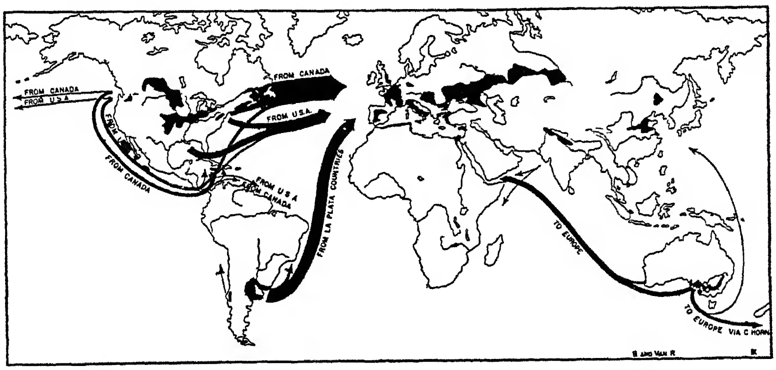


Fig. 260.—Principal wheat producing regions of the world, and wheat trade. (Based upon 1922-1923 to 1928-1929 average and adapted from Holbrook Working and P S King, "Graphic Representation of Wheat Trade," *Wheat Studies of the Food Research Institute,* Vol 6, No 10, 1930 Flour included in terms of wheat)

major producers. On account of their dense populations, however, they consume practically all they produce, and in normal years they even import considerable quantities. The principal producers from a commercial point of view are Russia, the United States, Canada, Argentina, Australia, and the countries of southeastern Europe. Argentina and Australia, both of which play an important role in the world's wheat trade, rank below France and Italy in total output, but their sparseness of population and absence of important industrial districts enable them to export a large percentage of their crops.

Wheat in North America—limits of wheat cultivation.—One of the world's principal centers of commercial wheat production lies in North America from northern Texas to the Peace River district of Alberta. It is limited on the north by the short and cool summers of the subpolar climate, on the south by the increasing heat and humidity of the subtropical climate of the Gulf Coast region Eastward, cotton and corn replace wheat in the southern half of the belt because they give larger returns per acre Farther to the north dairy farming encroaches upon wheat raising.

To the west the percentage of wheat acreage gradually decreases with the increase in aridity Along the entire western margin of the wheat belt lies a broad strip where wheat farming, and for that matter tillage agriculture in general, is decidedly marginal The fluctuations in rainfall from year to year make farming a hazardous enterprise. In some districts the precipitation of one year regularly falls below the minimum necessary to raise a crop, and the accumulated precipitation of two or more years is used for one crop by means of "dry farming" methods.

In this marginal zone the western limit of commercial wheat production swings back and forth During periods of comparatively heavy rainfall and favorable prices, agriculture tends to move westward. In dry years, and in periods of economic uncertainty, agriculture retreats before the advance of the rancher. This region is truly a "permanent pioneer belt"

In North America the wheats grown east of approximately the 95th meridian are predominately of soft and starchy texture, while those of the less humid regions to the west of this line are, with the exceptions of those grown in the Pacific Coast states, hard and vitreous, and generally of higher protein content These bear the market classifications of soft and hard wheats respectively. The hard wheat belt of the Great Plains is the foremost producing region of North America.

The hard red spring wheat region.—The American hard wheat belt can be divided into two sections, the northern and the southern, separated by a narrow gap in northeastern Nebraska

where wheat is of little importance The northern section, in Alberta, Saskatchewan, Manitoba, North Dakota, South Dakota, and Minnesota, occupies the larger area and is the more important of the two. On account of the long, cold winters, spring sown varieties are grown almost exclusively; therefore the region is commonly referred to as the *hard red spring wheat region*. The climate is subhumid to semi-arid. The soils belong to the groups of the blackerths, chestnut brown, and prairyerths, and thus they are rich in plant foods. The wheat is of excellent quality, hard and with a high protein content. Considerable durum wheat is grown also in this region. While it is not well adapted for breadmaking, it is highly esteemed in the manufacture of such wheat products as macaroni and spaghetti.

Most of the Canadian and a large percentage of the United States spring wheat is exported via the Great Lakes waterway, through the Canadian ports of Fort William and Port Arthur and the American ports of Duluth and Superior. The principal export centers are Montreal, New York, Philadelphia, Baltimore, and St. John. Much of the American spring wheat goes to various interior milling points, of which Minneapolis is the most important.

The hard red winter wheat region.—The southern section of the wheat belt embraces parts of Nebraska, Kansas, Oklahoma, and Texas, the state of Kansas ranking first by far in production This is the *hard red winter wheat region.* In this area the winters are so short and mild that the grain can be sown in the fall The wheat is not quite so hard as that grown farther north, but it nevertheless is a highly desirable type for milling into bread flour. While much of this grain moves to interior primary markets and reshipping points, such as Kansas City, St Joseph, Omaha, and St Louis, more than a fourth of the crop is shipped to coastal points, especially Galveston and New Orleans, and exported from there. The hard red winter wheat region is the foremost source of wheat exports from the United States.

The soft winter wheat region.—To the east and south of a

line running approximately from Tulsa, through Kansas City and Chicago, to Toronto lies the *soft winter wheat region,* which reaches across the Appalachians to the Atlantic Coast in New Jersey, Delaware, and northern Virginia This area is bordered by the Corn Belt and the hay and dairying region on the north and by the tobacco country and the Cotton Belt on the south The wheat grown is mostly winter sown, red, and rather soft on account of greater humidity On the whole it is not so well suited for bread flour as are the harder varieties grown farther west, but it makes high quality pastry flour Some soft white winter wheat is grown in southern Ontario and western New York Although the soft red winter wheat accounts for nearly a third of the total wheat acreage in the United States, most of it is consumed within the country and but little of it enters international trade

The Columbia Plateau region —Another important center of wheat production is located on the Columbia Plateau of Washington and Oregon Various types are grown in this region The climate is mild, and although both hard red winter and hard red spring wheats are grown, the softer varieties, such as white club wheat, dominate Most of the crop is consumed in the western part of the United States, but large quantities are exported from Portland and neighboring Pacific ports to Europe and the Far East

Canadian and United States exports.—The United States can and usually does produce much more wheat than is needed to meet domestic demands It is a cash crop, and it is better adapted to the climatic conditions of a large part of the subhumid plains than is any other grain Therefore the wheat farmer has been greatly dependent upon foreign demands for the disposal of his surplus In recent years competition on the world market has become increasingly difficult for the farmer, partly as a result of greatly increased production in the other exporting countries and partly as a result of the protectionist policies of many of the importing countries as well as that of the United States. Consequently, exports have declined so that now the United States ranks below Canada and Argentina.

Canada holds first rank in wheat exports among the countries of the world, chiefly on account of the sparse population and the large areas of prairie lands suitable for the production of this crop

Wheat in Argentina—climate and soils.—The wheat region of South America is located in a huge semicircle around the estuary of the Parana River, the Rio de la Plata Because of its peculiar outline this district is often referred to as the "wheat

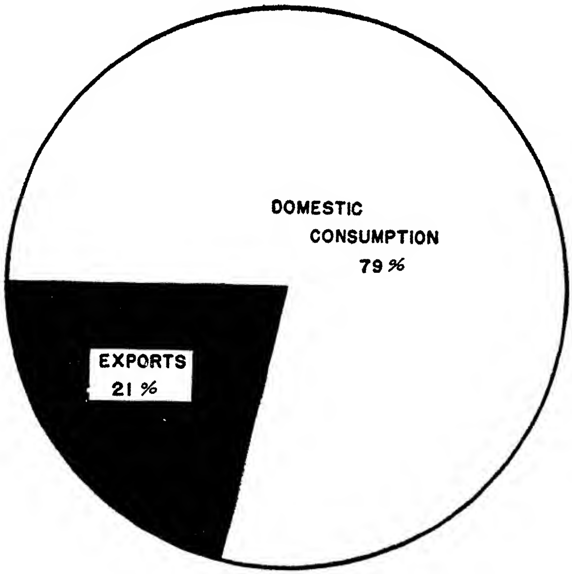


FIG. 261.—Domestic consumption and exports of wheat in the United States. Average 1921-1930 (Source of data Yearbooks of the United States Department of Agriculture, Washington, D C)

crescent" of Argentina In Uruguay wheat production is of small but of increasing importance. The latitude of the "wheat crescent" corresponds to that of northern Texas, Oklahoma, and Kansas. Thus it may be compared with and actually is competitive with the hard red winter wheat region of the United States As a result of the narrowness of the land mass of southern South America, continental influences are much less pronounced in the climate of the eastern Argentine than in the corresponding parts of the United States The winter tempera-

tures are mild, with temperatures only occasionally below the freezing point, and the summers are hot The climate can be classified as humid subtropical. Over much of the area, however, precipitation is lower than in other regions with a similar climate. It ranges from approximately 40 inches in the neighborhood of Buenos Aires to 20 inches near the western edge of the Pampa region proper. From here westward and southward it decreases rather rapidly to 10 inches and less. The soils of the La Plata area are derived from loess and loess-like materials, and, although often slightly more leached, they bear strong resemblance to the fertile dark soils of the middle western part of the United States.

Wheat farming as an adjunct to the cattle industry.—The natural vegetation of this section of Argentina and the neighboring lands in Uruguay is grass—the *Pampa*. As in other grass land areas, livestock raising was once the only important agricultural activity, and to a large extent it still dominates the economic life of the country In most districts the cultivation of wheat is carried on in close association with the cattle industry Areas of land are leased by the owners for short periods to immigrant share tenants, the majority of whom are of southern European origin At the end of the leasehold the tenant is required to leave the land in alfalfa, for which it has been prepared by the cultivation of wheat during several successive years. The tenant usually moves on to some other piece of land, where the same process is repeated As a result of this migratory system of farming, yields of wheat are low Nevertheless, with the sparse population of the country, export surpluses usually are large The harvest takes place during November, December, and early January; thus the wheat can be marketed when stocks in Europe, the principal center of consumption, are beginning to run low. Cheap land, cheap labor, good railroad facilities, and proximity to ports such as Buenos Aires, Rosario, and Bahia Blanca aid in keeping down the costs of transportation. Argentina, therefore, is an important factor in the world wheat market, ranking second only to Canada as an exporter. Large areas are still available for

wheat, and if market conditions should warrant it, production could easily be doubled.

One of the main problems which faces the Argentinian wheat industry is that of transportation from farm to railroad In a loess region, where stone is scarce, roads are expensive to build. Storage facilities also, especially in the country, are inadequate, resulting in a rush to market as soon as the crop is harvested This practice sometimes depresses the price of the grain on the farm to unwarranted levels

Wheat in Australia.—In Australia wheat is the principal grain crop, occupying over half of the area of tilled land. It is grown almost entirely in the regions where the dry subtropical climate prevails, the leading states being New South Wales, Victoria, South Australia, and West Australia The winter rainfall ranges from 10 to 20 inches, at other seasons the rainfall is slight. In many districts dry farming practices are necessary to assure a crop.

Seeding generally occurs in the fall—i e., in April and May—and harvesting is done in late spring and early summer, the beginning of the dry period Australia thus enjoys the same commercial advantage as Argentina—namely, it is able to market its crop early in the year. The principal handicaps of wheat growing in Australia are: (1) great distances from the European market centers, and (2) the unreliability of rainfall, which leads to great fluctuations in production While Australia ranks below France and Italy in total production, on account of its small population it ordinarily consumes less than half of its crop, and so holds fourth place in export trade Most of the wheat is shipped westward to Europe, but annually considerable quantities are exported in tramp sailing vessels via Cape Horn, giving rise to the so-called "grain race" to English ports In recent years, however, the Far Eastern countries, especially Japan, have become of some importance as markets for Australian wheat.

Wheat production in Europe—climate and soils.—Although much wheat is produced in western and southern Europe, particularly in France, Italy, Germany, and Spain, it all

enters domestic consumption The principal European export centers lie in the plains in southern Russia, in the Lower Danube Basin of Rumania and Bulgaria, and in the Hungarian Basin.

In all three of these regions the climate is decidedly continental, with cold winters and hot summers The seasonal distribution of rainfall, with spring and early summer maximum, is favorable for wheat production The amount of annual rainfall decreases eastward In the Hungarian Plain it

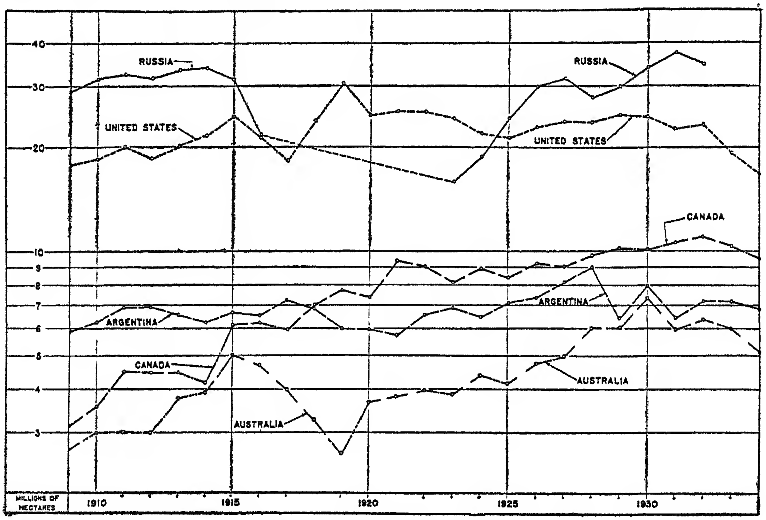


FIG. 262.—Trends of wheat acreage in principal producing countries since 1909. Logarithmic graph (Source *International Year Book of Agricultural Statistics*, International Institute of Agriculture, Rome)

ranges from 28 to 20 inches, in the wheat districts of Rumania from 24 to less than 16 inches; still farther east, in Soviet Russia, it decreases to an average of 12 inches in the lower Volga districts near Saratov. The natural vegetation over most of these areas was, and to a certain extent still is, grass; the soils generally are fertile, either chernozems or chestnut brown steppe soils.

In the Danube Plains and in southernmost Russia, winter wheats predominate. In most of Russia, however, the snow cover is too light to protect the plants from the effects of the

severe winters, and therefore spring sown varieties must be grown. In most of southern Russia the wheat industry is subject to the same handicaps as in the Great Plains of the United States. Winter snows and spring and early summer rains fluctuate greatly in amount from year to year and deficiency of moisture often causes crop losses and sometimes famine conditions It is in this part of the world that "dry farming" was first practiced

The belts of black and chestnut brown soils on which most of the wheat of European Russia is grown extend across the Ural Mountains into Siberia. They gradually become narrower, and east of the Yenisei River they break up into isolated areas which possibly connect with the brown and black soils of Mongolia and the Manchurian Plain Wheat cultivation has followed these belts far eastward into Siberia. Distance from population centers and world markets, however, is a great handicap in this part of the Russian state

The quality of wheat improves from west to east with increasing aridity. The wheats of the Hungarian Basin, and especially those of Rumania, are comparable with the hard red winter wheats of the United States, and with the best produced in Canada and northern United States

Other wheat producing areas.—Among the other wheat producing areas of the world should be mentioned northern Africa, northern British India, northern China, Manchukuo and Chosen The commercial importance of these areas is, however, relatively small.

Wheat as a commodity of international trade.—Wheat not only keeps well in storage and transportation but it is in great demand as a basic foodstuff in many parts of the world, especially in the middle latitudes. Although in some countries, as in the United States, the per capita consumption has contracted slightly as a result of changes in the diet, in other countries, as in Japan, the demand is growing. In order to make good bread flour a considerable amount of blending is advisable. Wheat, therefore, has become one of the principal articles of the world trade in raw products, and the trade in flour likewise

is highly important, the United States being the leading exporter of this commodity

The principal centers of consumption and deficit production are western Europe and the eastern United States Both areas are not only densely populated and highly industrialized, but climatically they are better adapted to other crops than they are to wheat Of the two, Europe is the more important Large quantities of wheat are shipped there each year from Canada, Argentina, Australia, and the United States. Russia and the Danube Plains likewise find important export markets in western and southern Europe. In recent years the demand for wheat in Japan and China has increased materially—a trade served chiefly by Canada, the United States, and Australia.

RYE

As a bread grain rye is much less satisfactory than wheat. The flour makes rather poor bread when used alone. The bread is dark colored, compact, and usually soggy inside It is generally referred to as "black bread," although its color is only a dark brown In Europe rye bread is commonly looked upon as the bread of the poorer classes Because of its poor quality and the social stigma attached to its use, a popular prejudice against it has developed Wherever people can afford to do so, they eat wheat bread, or rye bread with a considerable admixture of wheat flour

The importance of rye as a bread grain is slowly declining Nevertheless, in considering the food situation in countries such as Poland and Russia, or even Czechoslovakia or Germany, the rye crop is a factor which cannot be ignored. In Russia the rye acreage closely approximates that of wheat, and the total quantity of rye produced often exceeds that of wheat. Although on the whole rye has decreased in importance as a breadstuff, on the other hand it has increased in importance as a feed crop, and therefore the world acreage has tended to remain about stationary.

Rye as a crop of poor soils.—Where soils are leached and too poor for wheat, and where the climate is too raw, rye is a

grain that may still give a satisfactory yield. It needs less heat and can stand more moisture Winter rye survives where most of the winter wheat would be frost-killed. Rye is autumn-sown in most places, but both as a winter and a spring grain it reaches much farther north than does wheat.

While it is grown to some extent on fairly good soils, rye is the typical grain of the poor, leached podsols which have developed upon the sandy glacial mantle rock and under the cool, moist climatic conditions in continental Europe north of the fiftieth parallel. Farther south rye occurs locally in areas of poor soil, unfavorable climate, or both, as on the Central Plateau of France, in Brittany, and on some of the sandier soils of the Hungarian Plain Little rye is grown outside of Europe. In the United States the total rye acreage is small; the chief centers are in areas of comparatively poor soil and cool climate in North Dakota, Minnesota, and Wisconsin

In comparison with wheat, the world trade in rye is of little importance The principal exporting countries are Soviet Russia, Poland, Germany, and Hungary.

CORN

Although corn was unknown to Old World agriculture, it is now one of the most widely produced cereals. It is grown in every country in the New World from Canada to Argentina It is so tolerant of diverse climatic conditions that it can be produced where little rain falls, as in southwestern United States, or where heavy rainfall is characteristic, as in New England. It is grown on a commercial scale where the growing season is only 90 to 100 days long, and likewise where the season is twice or thrice that length. That it is also tolerant of different topographic locations is indicated by its range of cultivation from the low-lying coastal plains of eastern United States to the high mountain slopes of Colombia and Peru, where it thrives at altitudes exceeding 8,000 feet.

The cosmopolitanism of corn is revealed not only in its wide distribution but also by its variety of uses. It is used as a breadstuff, a veritable staff of life, by millions of people scattered

over the warm lands of the earth It is used more or less freely as a feedstuff for domestic animals in many of the temperate countries, and thus is a splendid raw material out of which swine and steers make choice pork chops and tender steaks Numerous prepared foods are made of corn, among which grits, hominy, cornflakes, and corn syrup are perhaps best known. Industrial products by the dozen are made from corn or corn stalks; as illustrations may be mentioned starch, alcohol, paper, rayon, fiber boards, and corn rubber Corn cobs are extensively used as domestic fuel, and their picturesqueness when made into cob pipes has, of course, long been recognized

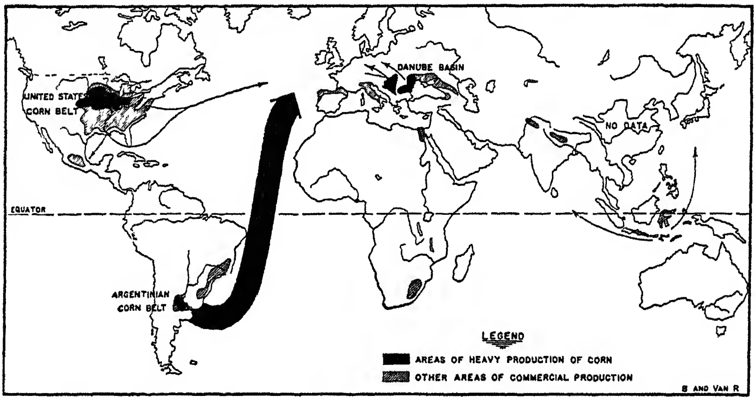


FIG. 263.—Principal commercial corn producing regions and international trade in corn.

Importance of corn to American colonists.—Maize first sprang into economic importance with the settlements of Jamestown and Plymouth. There the English colonists found it being successfully cultivated by the Indians, who depended upon it as their foremost cereal food. Under the early pioneer conditions it had some distinct advantages over the imported European rye, oats, and wheat The small grains could not be produced so easily on uncleared ground as could the more individualistic corn. For wheat culture fields needed to be plowed, and this demanded beasts of burden and implements not included in the meager assets of the first colonists Here

the individuality of the corn plant proved to be distinctly advantageous Girdling trees was a simple process, and standing dead trees were but little hindrance to corn culture. The separate hills of corn could be fertilized with fish Cultivation was practiced with the most simple tools, and the harvest was a leisurely process of gathering the ears when time and circumstances proved convenient. Other significant factors included the possibility of safe storage of the grain at relatively small expense and the practicability of preparing into various palatable dishes No wonder that corn became recognized as a life saver by the colonists, and that its introduction into white agriculture has won a hallowed place in history.

Westward expansion of corn production in the United States.—"Coming events cast their shadows before." The well-known adage is applicable to the extension of corn production by the Europeans who first settled along the coast of the North Atlantic. The experiences of the early colonists projected long shadows across pages which have become agricultural history The factors which made corn profitable to the colonial pioneers made it a profitable crop under similar conditions farther westward. The early frontier in the eastern half of the United States was largely one of corn culture among dead, girdled trees. The land was cleared slowly, but was made productive of crops before trees and stumps were removed. The corn was planted by hand, tended with a hoe, and the ripened ears picked and gathered into sacks The essential tools and implements needed for westward migration were thus reduced to a minimum in both number and bulk

Corn production, long practiced by the Indians, moved westward slowly over the hilly, forested lands The advancing wave of farmers depended upon the crops of corn to furnish food for man and feed for the animals while new lands were being cleared, settlements extended, and transportation facilities provided. During all this time of slow advance over woodlands to be cleared for farming, corn was important as a subsistence crop rather than as a cash crop.

With the opening up of the prairie lands the picture changed,

grasslands needed no clearing because they generally were treeless and free from bowlders The soil was rich and the summer rainfall ample for the heavy demands of growing corn Large fields and surplus production resulted, quite in contrast to the small fields and local subsistence crops of pioneer days in the eastern woodlands As previously pointed out (pp. 192-7) the period 1830-1860 marked the conversion of the humid grasslands of the Mississippi Valley from an area of grazing to one of grain farming These lands together with adjacent cleared forest lands then became and have since remained the great and well-known Corn Belt of the United States

The American Corn Belt.—The Corn Belt extends from central Ohio to central Nebraska, a distance of nearly 900 miles. Its width, north and south, varies from about 150 to more than 300 miles. The states leading in total production are Iowa, Illinois, and Nebraska, generally holding first, second, and third places respectively Although corn is widely grown on every continent, nowhere else does such a large stretch of land possess nearly optimum conditions for its production The climatic factors include a growing season of 120 to 160 days, rainfall of 25 to 40 inches per year, and summer temperatures averaging 70°F, with the midsummer period one of tropical warmth Rainfall is heaviest during the summer months, most of it of the thunderstorm type It reaches its apex in July, is quite heavy in August, and tapers off to a minimum in autumn and winter. The growing season is favored with a high percentage of sunshine, an important factor in promoting growth of the plant The dry, cold winter season facilitates storage at low cost with small percentage of loss by shrinkage or by insect pests, this is of great economic importance whether the corn is marketed directly as grain or indirectly through the feed lot as pork or beef Soils are fertile and easily tilled, in the eastern sections, where rainfall is the heavier and soils therefore the more leached, mineral fertilizers are used advantageously, while in the western sections of lower rainfall they are not needed. The plains topography is conducive to the use of machinery and to large-scale operations

Other geographic factors also contribute to the success of the Corn Belt farmers. Nature placed coal, petroleum, iron and copper ores, and extensive timber resources in and about this agricultural region. These are the raw materials of industry. The ingenious and inventive pioneers found this to be largely a prairie region awaiting the plow, a land endowed not only with rich soil and stimulating climate but also with a wealth of mineral resources. The result we witness today is a rural lands-

Courtesy, Omaha Chamber of Commerce

Fig. 264.—Typical view of corn field in western part of the corn belt.

cape of large, productive farms dotted with and almost surrounded by metropolitan industrial cities.

Although the term "Corn Belt" is generally accepted as the designation for the area from Ohio to Nebraska and from southern Minnesota to northern Missouri, let it not be thought of as a one-crop country. Diversified farming is the general practice Only 50 to 65 per cent of all the land in grain is devoted to corn. Wheat and oats, tame hay, and other forage crops all hold prominent places in the agricultural scheme. Corn farmers are

also hog and cattle farmers Surveys have shown that 80 to 85 per cent of the crop land is used to produce feed for farm animals. A large percentage of the corn is fed to livestock without leaving the farm of origin Furthermore, large numbers of cattle from the drier plains west of the Corn Belt are shipped in for fattening before going to market as finished beef. These conditions have made of the Corn Belt a country great in cattle and hogs as well as in grain production They have also led to the establishment of numerous meat packing centers in and about the region, the greatest ones being Chicago, Kansas City, and Omaha.

Important types of corn produced in the Corn Belt.—At the outset of this discussion the cosmopolitan character of corn was pointed out There are hundreds of varieties of this New World cereal, and among them are found those of widely different tolerances Some mature in 90 days or less from time of planting, while others require more than twice as long Some are drought tolerant, others require great quantities of moisture. Some do well on lowlands, others are best adapted to higher altitudes But only a few varieties yield abundant returns per acre in proportion to the labor costs Among them are different varieties of *dent* corn (so named because the top of the kernel collapses slightly during the ripening process), and these find their most favorable natural conditions in the American Corn Belt. Added to the environmental factors of climate, soil, and topography are the economic factors of proximity to great industrial centers and presence of splendid transportation facilities which provide accessible markets for corn, especially when marketed as meat products. Corn is therefore a commercial crop of the first magnitude in the Corn Belt Nowhere else in the world does such a combination of favorable environmental and economic factors exist on so large a scale. For this reason the supremacy of the region as the land of corn has been attained and stands unchallenged, a position which seems assured for future decades and perhaps for centuries.

Corn in Argentina.—Argentina ordinarily produces less corn than does the state of Iowa, and yet it has the distin-

guished position of leading all the countries in quantities exported. The corn growing area centers around the lower Parana region, mostly south and west of the river; lack of adequate transportation facilities has retarded its expansion into suitable lands located northeastward The broad expanse of flat land in the Pampa is well suited to corn production. There are no trees or bowlders to clear away, the soil is fertile and easily tilled. In these respects, power farming could ask nothing more.

Climatically, the Argentine corn belt is not quite so highly favored as is that of the United States. While the annual rainfall averages only slightly lower, its distribution is less favorable and the danger of drought is greater. Not infrequently considerable rain falls during the picking season, thus interfering with the harvest and causing deterioration in quality. The winters are less cold and, when rains occur, storage is more difficult. Transportation facilities are inadequate in some of the corn producing sections, as are also the facilities for farm storage. As a result of these storage and transportation handicaps, heavy losses through spoiling ensue when rainy periods occur during the harvesting and marketing seasons.

Another handicap which corn production in Argentina occasionally faces is that of insect pests. Northwest of the grain country is a stretch of semi-arid land, a shrub and bush area which serves as a vast incubator for locusts and other insects. When their numbers become exceptionally large, and therefore the food supply of their native habitat proves to be inadequate, they sweep southeastward into the more productive areas and feast on the grainfields of the Pampa. On such occasions the corn crop suffers heavily. These various influences of drought, irregular rainfall distribution, and ravages of insect pests cause the production to fluctuate greatly.

Argentina has, however, the advantage of producing the exportable surplus near the sea Nearly all of the corn sold comes from within 200 miles of tidewater, and therefore transportation costs are at a minimum. The countries of northwest Europe are the most consistent buyers of Argentinian corn. Inas-

much as it is used there as feedstuff for the dairy and poultry industries, the small-kernelled flint corn is preferred. This type is characterized by small, dense kernels of low moisture content and high food value

One of the chief reasons, if not the foremost one, for the importance of Argentina as a corn exporting country has been the lack of development of the swine industry Argentinians are gradually turning toward improvement of their beef cattle and toward finishing them into higher quality for the market As part of this program swine are being introduced quite extensively, because by consuming some feeds wasted by the cattle they render the feeding of both together economically advantageous With increasing attention to finishing cattle for higher quality beef products and with expansion of the swine industry, the local markets will of course absorb more of the corn Since the potential corn area is quite restricted and most of it is now utilized, the pressure for export outlets will become less The percentage of corn exported may be expected to show a downward trend as domestic demands become greater.

Corn in Europe.—The corn belt of Europe lies, for the most part, just north of the regions having the mediterranean type of climate. The chief centers of production are in the valleys of the Po and the lower Danube, and in the Balkans, the principal producing countries being Rumania, Russia, Yugoslavia, Italy, and Hungary Any topographic map of Europe will reveal this corn belt as having a "crazy quilt" pattern of mountains and valleys The best and the poorest farming lands are in close juxtaposition. On the more fertile lowlands, corn shares the fields with other cereals, principally wheat, whereas on the rougher and steeper lands it is predominant over the other grains. The western coast of the Black Sea approximates the eastward limit of production, beyond which aridity precludes its successful cultivation Within the boundaries thus outlined corn is used both as feed for animals and food for man. There, as in parts of the United States, the dependence upon it as a food is a criterion as to the wealth of the consumer. Obviously the poorer mountaineers there, as in the southern Appalachians,

ly abundant, temperatures cool, and growing seasons comparatively short. The tolerance of oats for cool moist summers accounts for its prominence in northwest Europe, where it competes successfully with both wheat and rye In the United States its adaptability is shown in its wide distribution; in the south it is rotated with corn and cotton, and in the north-central states it is rotated with corn, wheat, and tame hay Furthermore, Kherson oats, a drought-tolerant variety, is grown in the Great Plains, whereas moisture loving varieties of oats from Scotland and from the North Sea countries are produced in the humid northeastern states

Production and distribution.—The chief centers of world production are: (1) in northern United States and southern Canada; (2) in northwestern Europe, and (3) in central and eastern Russia Minor centers are found in northern Ireland and eastern Scotland In all these areas oats thrives under the diverse climatic and soil conditions and fits well into the agricultural practices It provides both grain and forage feed and the labor demands for both planting and harvesting conflict but little with either wheat or corn

The total oats production of the world averaged 4,334,400,000 bushels yearly for the decade ending in 1931-1932 The United States alone contributed about 28 per cent of this amount. Other large producers were Russia, 18 per cent; Canada, 10.4 per cent; Germany, 9 4 per cent; and France, 7.4 per cent. Within the United States oats reaches its maximum production in the northern part of the Corn Belt and beyond it, extending northwestward into the spring wheat region of Minnesota and the Dakotas. The states leading in production are Iowa, Minnesota, and Illinois, the production of each generally ranging from 150 to 225 million bushels per year In oats, as in corn, Iowa easily holds first place.

Although production is widely distributed in the humid intermediate countries where horses are used as power animals, international trade in oats is small. Ordinarily only two to three per cent of the world's crop enters the channels of international trade. Oats are raised where used wherever local con-

ditions permit. The straw is valuable for fodder, and that even the grain is bulky in comparison with other grains is shown by its low weight per bushel only 32 pounds, whereas a bushel of wheat weighs 60 pounds These factors, the value of the straw for feed and the bulkiness of the grain, militate against transportation and promote local production Oats, therefore, is largely a subsistence crop, with its chief markets near the districts where grown.

BARLEY

Barley was probably among the earliest cultivated cereals. Grains of the six-rowed species, believed to date back to predynastic periods, have been discovered in Egypt, and similar remains have been found in Switzerland. A two-rowed kind, also of great antiquity, appears to have been derived from a wild species, *Hordeum spontaneum,* which is found now in dry situations in southwestern Asia For untold centuries barley has been the breadstuff cereal depended upon by people who live near the desert's edge.

Uses and qualities.—Barley ranks high in food value, but as a breadstuff it has failed to win high favor because its gluten content is too low for the making of soft light bread. It is, however, widely used for soups and porridge, for specially prepared foods for babies and invalids, and is winning favor as a breakfast cereal In case of wheat shortage the use of barley offers a practical avenue of escape from a bread famine

Barley is used extensively for making malt. For this purpose the grain should be plump, thin skinned, of pale color, and of high germinating quality. It should be rich in starch and relatively low in protein content. The color should be clear and uniform, because discoloration precludes its use in the making of malt to be used in the manufacture of beer ale, or whiskey.

Grains from which the husk has been removed by coarse grinding are known as "pot barley." The rounded grains of "pearl barley" used in soups are obtained by continuing the grinding process until the husk has been completely removed

One of the chief uses of barley is as a feed for domestic animals. Unlike oats, the straw is of little value and therefore is used chiefly for litter The grain, however, makes good stock feed, and since barley yields well per acre it is in high favor as a forage crop for hogs, cattle, and horses, particularly where corn cannot be grown In countries having winter rain and summer drought and where horses are popular, as in California and Australia, it is often cut before the grain is mature, in order to use the whole plant as hay. In this manner it makes an excellent fodder crop

Range of cultivation.—Barley can endure a wider range of temperature than any other cereal It grows well within the Arctic Circle in northern Sweden, Finland, and Russia, and also in dry subtropical and tropical climates as in northern Africa and British India It is grown at altitudes varying from sea level to 14,000 feet and constitutes, for example, the principal grain crop on the high plateaus of Bolivia and Tibet It is much more drought-tolerant than wheat, but cannot stand as much rain. While it is grown extensively in all countries of intermediate climate, it is the principal grain only where climatic conditions are too unfavorable for wheat or rye, as at the edge of the deserts, near the cold limits of vegetation, and at high altitudes.

Centers of production.—Among the continents, Europe holds first rank in barley production; Russia, Germany, and Spain are there the largest producers The major centers outside of Europe are northern Africa, Turkey, British India, Japan, and north-central United States Barley production is more widespread than that of oats. Compared with wheat it extends farther north in Europe and farther into the arid regions of northern Africa and western United States Its wide distribution results from its ability to mature in the short summer of high latitudes and in the short rainy season of the semi-arid lands.

International trade.—International trade in barley is much more extensive than in either rye or oats During the past decade six to ten per cent of the world crop has entered export

trade, the principal countries being Russia, Rumania, the United States, and Canada Since it is a crop raised largely on marginal lands, the yields vary greatly in any region from year to year, and hence the quantities available for export fluctuate widely Thus, the rank of exporting countries is likewise subject to change in different years. The principal importing countries are located in northwest Europe, where there are large demands for barley to be used for malt and for feedstuffs, the latter being particularly important in connection with dairying centers in Denmark, the Netherlands, and eastern America.

SOY BEANS

The soy bean bids fair to become an important crop in all middle latitude climates. At present it is produced on a large scale only in the Far East on the fertile lowlands of the Yangtze River, the delta plains of the Hwang Ho, and particularly in the northern part of the Manchurian Plain. Botanically it is characterized by a large number of varieties, each of which is adapted to certain conditions of climate and soil The length of the growing season required by these numerous varieties may range from less than three to more than six months This variability makes the production of soy beans possible from Java to northern Manchukuo (Manchuria).

The bean is valuable as a food and a feed because of its high content of proteins and fats In China and Japan soy beans are used for human consumption in many forms, as sprouts, as fresh or dried beans, as a meal for making noodles and for other dishes, as a cheese-like substance (the so-called bean curd), for the preparation of various sauces, and for the extraction of oil and the manufacture of bean cake.

Commercial importance.—It is for the latter two purposes that the beans are of greatest commercial importance The Manchurian Plain is not only the principal producer but also the main exporter The oil is suitable for many industrial purposes, especially for the manufacture of oleomargarine and soap. The residue, soy bean meal, is pressed into cakes, and be-

cause of its high protein content it is valued as a feed and also a nitrogen fertilizer. In the Netherlands and Denmark it is used extensively as a supplementary feed for dairy cattle, while Japan imports large quantities of bean cake to serve as fertilizer on its rice fields and mulberry plantations

The United States ranks fifth as a producer of soy beans, being surpassed by Manchukuo, China proper, Korea, and Japan. The beans are raised primarily for feed, especially in Illinois, Indiana, North Carolina, and Louisiana The total acreage is increasing slowly, a trend which may be expected to continue in the future

SUGAR BEETS

About one-third of the world's production of sugar is derived from sugar beets, a crop which can be grown successfully only in intermediate climatic regions, where the summers are neither too hot nor too humid, and where the growing season is at least 130 days long.

The sugar must be extracted from the beets by processes which necessitate the construction of large and expensive plants Thus, while in the tropics much sugar cane is raised both for home consumption and for commercial purposes, the sugar beet is a strictly commercial crop which must be sold to a nearby factory

Climatic requirements.—The sugar beet is a plant which makes rather exacting requirements upon climate, and even more upon soils. Summer temperatures should be moderate In the United States it has been found that in the regions most favorable for the cultivation of sugar beets, hot spells are rare and the average temperatures of the summer months do not depart much from 70°F. The supply of moisture must be ample, but a cool, dry period immediately preceding and during the harvest is essential for a high yield of sugar The soil should be not only fertile but also deep and friable in order to allow the unhampered growth of the beet.

Principal beet growing districts—As a result of these physical and economic factors the production of sugar beets is lim-

ited to certain regions in which optimum conditions prevail. Europe accounts for more than 85 per cent of the world production of beet sugar Beets are grown in nearly all countries, but their cultivation is successful only on the most fertile soils, as, for example, on the loessal soils of northern France and Belgium, on those of the Magdeburg district in Germany, on those of Bohemia and Moravia in Czechoslovakia, and on the rich black soils of the Ukraine in Russia. The countries leading in production of beet sugar in Europe are Germany, Russia, Czechoslovakia, France, and Poland.

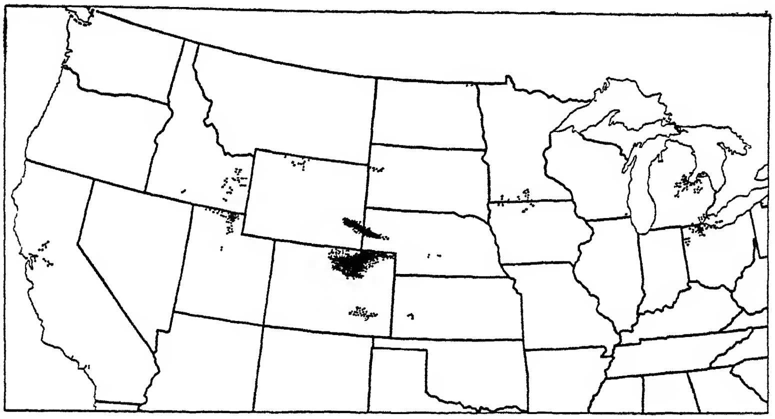


Fig. 265.—Map of sugar beet districts in the United States. (Prepared by Dr Esther S Anderson, University of Nebraska)

In the United States the cultivation of sugar beets is limited to the best glacial silt and clay loams east of the Mississippi and to the unleached pedocalic soils of the semi-arid regions farther west. While in Europe the bulk of the crop is grown on non-irrigated land, in the United States the most important producing regions, with the exception of eastern Michigan and northwestern Ohio, are all under irrigation. The principal sugar beet districts are the irrigated valleys of the Great Plains from Montana to southern Colorado, the Snake River Valley in Idaho, the Great Salt Lake Basin of Utah, and the Great Valley and southern coastal plain of California.

An intensive culture.—The sugar beet is particularly well

adapted to a system of intensive agriculture as it is practiced in most of Europe since it requires deep ploughing and careful tillage, the application of much manure and fertilizer, and the use of a large amount of cheap hand labor in the thinning and weeding of the fields The by-products of the industry, beet tops and pulp, can be used to advantage in the fattening of cattle.

Beet sugar versus cane sugar.—Since the yield of beet sugar per acre is generally lower than that of cane sugar, and the cost of production is much higher, almost all beet producing countries protect their industry by means of tariffs against the competition of tropical sugar The international trade in beet sugar is not as important as that in cane sugar It is confined mostly to Europe, where the principal exporters are Czechoslovakia, Poland, Germany, Belgium, and Hungary

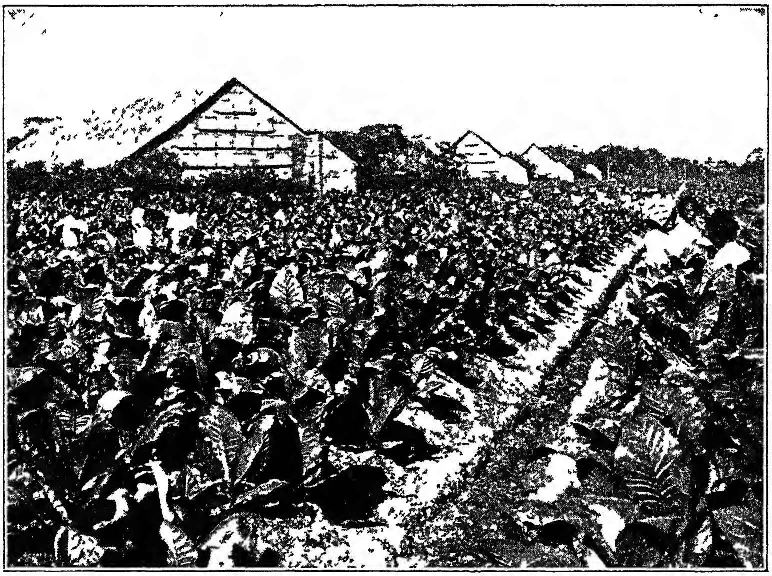
TOBACCO

Tobacco is truly a cosmopolitan, in regard to its consumption as well as its production In some form or other it is a product used by practically all peoples of the world, while its adaptability to climatic conditions is such that it can be grown in the equatorial belt or in the northern part of the temperate zone. It is produced successfully in Ecuador and Sumatra on the one hand, and in southern Sweden and Canada on the other Hence it is evident that temperatures and the length of the growing season are not such vital factors in the growth of tobacco as they are in that of many other crops

The influence of soils.—The geographic distribution of tobacco is influenced by soil rather than by climate. The tobacco plant, esteemed for the flavor and aroma of its leaf is, as the wine grape, highly sensitive to slight differences in soil The exact properties of a soil which affect the quality of the leaf are not well known, but experience has taught that some areas are better suited to tobacco than others. As a result of this circumstance and of the economic inertia caused by established taste and purchasing habits, tobacco shows a spotted distribution notwithstanding its wide climatic range. Certain

types of tobacco are quite rigidly bound to certain areas, and much of the tobacco of the world is sold on place name specifications, as, for example, Maryland pipe tobacco, Virginia cigarette tobacco, or Deli cigar wrapper. In this connection it is interesting to note that an important center of Indian tobacco raising was located in Kentucky and Tennessee, an area which now is one of the principal producing districts of the world.

Climatic requirements.—A native of Mexico, Central Amer-



Courtesy, Deli Proefstation, Medan, Netherland India

Fig. 266.—Field of leaf tobacco in Sumatra. Drying sheds in background.

ica, and Brazil, the tobacco plant prefers considerable warmth and does not thrive in a semi-arid environment unless, of course, irrigation water is available. Thus, most of the major producing districts have developed in the southern part of the temperate regions and along the northern margin of the tropics Since the areas of the world's greatest commercial production are located in the United States immediately north of the Cotton Belt, it appears justifiable to treat the tobacco industry in connection with the middle latitudes

Curing of tobacco.— Not only soil and climate, but also variety and mode of curing the leaf affect profoundly the quality of the final product and, therefore, the use or uses to which the tobacco can be put. The trade recognizes three well-known classes based upon the methods used in curing the leaf; namely, air cured, fire cured, and flue cured Air cured tobaccos are treated in well ventilated barns without the use of artificial heat. Fire curing takes place in barns about three to five days after the leaves have been hung. Open fires are made on the floor of the barn and kept burning for several days The smoke of these fires affects the tobacco and gives to it characteristic odor and taste In flue curing also artificial heat is applied, but large pipes or flues carry off the smoke so that it does not come into direct contact with the leaves. A rather light colored tobacco results from this process

Tobacco in the United States.—*Flue cured tobaccos* are grown on the light loamy soils of the piedmont region of North Carolina and southern Virginia and on the poor sandy soils of the Atlantic Coastal Plain of Georgia, northern Florida, and the Carolinas. Most of the flue cured tobaccos are used in the manufacture of cigarettes The development of the tobacco industry in these regions well illustrates how agriculture may be affected profoundly by changes in habits of consumption. The increase in the demand for cigarette tobacco has led to a great expansion of the acreage of flue-cured tobaccos, adding in relatively recent times the state of Georgia to the list of tobacco producers, and greatly enhancing the importance of the North Carolina and Virginia tobacco industry, which centers around Durham and Winston-Salem

Fire-cured tobacco is produced in the Piedmont of central Virginia and in the extreme western parts of Kentucky, in the so-called "black patch" Its use is relatively limited, and the acreage is slowly decreasing.

Among the *air cured types* the Burley tobaccos of the Kentucky Blue Grass Region and adjoining areas stand first. These tobaccos are in demand primarily for the manufacture of pipe tobacco, but also for that of cigarettes. The darker and thick-

er leaves are used for the former, the lighter and thinner types for the latter purpose In the marginal districts of this area, in Indiana, Ohio, and West Virginia, a decrease in acreage is noticeable. In the southern part, however, it is expanding toward the foot of the Crystalline Appalachians.

Tobaccos used in cigar manufacture are also included in the air cured group. In the United States the quantities involved are much smaller than are those of the cigarette and pipe tobaccos. The areas of production are comparatively small and are scattered through the states farther to the north and west, Wisconsin being one of the leading states. The most interest-

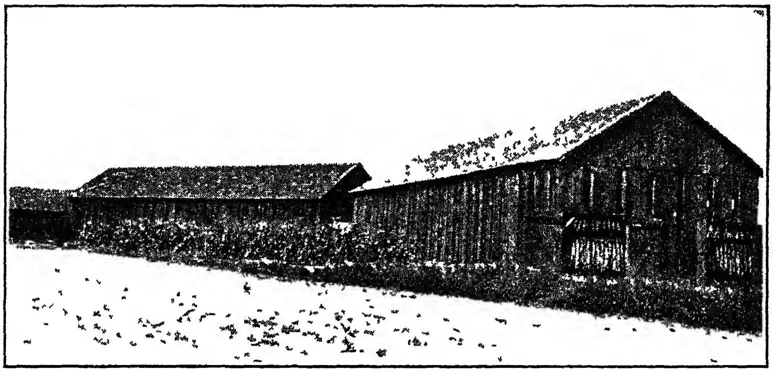


Photo by N A B

Fig. 267.—Tobacco drying shed in the Connecticut Valley. Bunches of tobacco leaf can be seen through the open gates.

ing feature of this aspect of the tobacco industry is the growing of cigar wrappers in the valley of the Connecticut River and in Florida For this purpose the leaves need to be thin, light colored, and large Therefore, the plants are grown under artificial shade of cheese cloth or laths.

Tobacco in Europe.—In Europe much tobacco is grown locally, partly because in many countries the manufacture and sale of tobacco products has been made a state monopoly for revenue purposes From a commercial point of view the principal producing regions lie in Greece, Bulgaria, and Turkey. There are grown the famous Oriental or "Turkish" tobaccos, especially prized for the manufacture of cigarettes. Among the

best known are the tobaccos of Cavalla and Xanthe, grown on the north shores of the Aegean Sea.

Other tobacco producing centers.—In Asia, British India is by far the largest producer, ranking in acreage and production next to the United States. Most of the tobacco, however, is consumed locally; only relatively small quantities, and they of inferior quality, reach world markets

Netherland India ranks next to the United States in commercial importance. In Sumatra some of the choicest wrapper tobaccos of the world are grown on estates under European management, located on the fertile, volcanic soils of the Deli region, where western initiative has transformed a tropical jungle into a flourishing agricultural district. The eastern half of Java also produces much cigar tobacco, partly on estates, partly on native lands.

The Philippines have long been famous for their excellent cigar tobaccos "Manila" cigars are known the world over The best tobacco, nearly all of cigar-leaf grade, is grown in the wide valley of the Cagayan River in northern Luzon.

The most valuable cigar tobaccos are grown in Cuba, Havana cigars being generally accepted as the world's best The highest grade tobacco is grown in the Vuelta district, of westernmost Cuba, and adjoining areas The crop is raised by a large number of small farmers The plant is generally grown under protecting cheese cloth

Other important centers of tobacco cultivation are found in the states of Bahia and Rio Grande do Sul of Brazil, the former producing tobaccos for cigar manufactures, the latter primarily for cigarettes.

Tobacco in international trade.—The United States ranks as the world's principal exporter of tobacco and tobacco products, in normal years sending more than two-fifths of its production abroad, mostly to Europe The exports of tobacco bring millions of dollars into the United States yearly. At the same time the United States imports (although in much smaller quantities, usually not more than 10 per cent of the domestic production) such qualities of tobacco as it cannot grow within

its own borders. Part of these are reëxported in the form of cigarettes.

The "Turkish" tobaccos of the eastern Mediterranean are exported mostly to western Europe and to the United States Nearly all the export tobacco of Netherland India is shipped to Amsterdam, where it is sorted and made ready for the auctions A large percentage of the finest qualities of these tobaccos reach the United States. The Cuban exports, both cigars and leaf tobacco, go chiefly to the United States, where the latter has, among others, given rise to the extensive cigar mak-

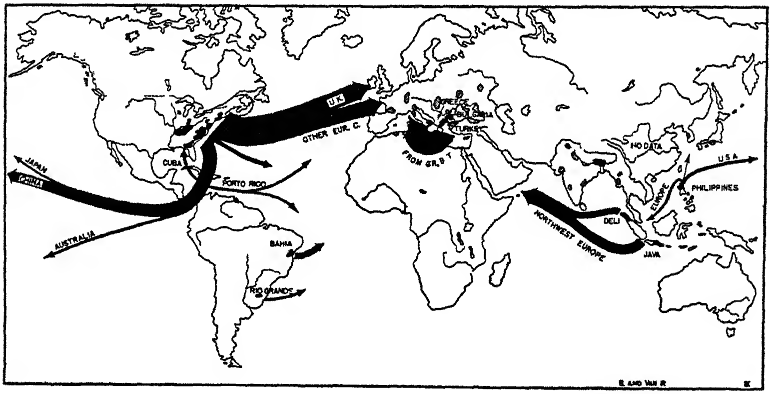


Fig. 268.—Principal tobacco growing regions of the world, and trade in tobacco.

ing industry at Tampa, Florida. The Philippine exports likewise consist of both cigars and leaf tobacco, for which the principal markets are found in the United States, Europe, and the neighboring Far Eastern countries.

The tobacco industry furnishes an excellent example of the great desirability and often the necessity of unhampered world trade. The differences in quality of tobaccos grown in various parts of the world quite naturally invite exchange, especially since extensive blending is practised in both the cigarette and the cigar industries The United States, as the principal exporter, has probably the greatest stake in the maintenance and further development of the international trade in tobacco.

FLAX SEED AND FLAX FIBER

In former times flax was the textile material which, with wool, served for the manufacture of clothing in all regions of temperate climate. The fiber lost much of its importance with the advent of cotton, and at present most of the flax of the world is of the variety which serves primarily for the production of seed, and which does not produce a fiber suitable for textiles.

Flax seed can be produced under greatly varying climatic conditions, but it generally does best on soils which have just been placed under cultivation Large seed-producing regions are the Pampa district of Argentina and Uruguay, the states of North Dakota, South Dakota, Minnesota, and Montana, and in British India and Soviet Russia. The oil of the flax seed, the so-called linseed oil, is used extensively in the manufacture of paints and other products, and linseed cake is an important stock feed Argentina and British India are the only large exporters of linseed The principal importing countries are the United States, the Netherlands, Germany, the United Kingdom, and France The only important exporter of linseed oil is the Netherlands.

Fiber flax.—Flax produced for seed can stand rather high summer temperatures and even conditions of drought, but the production of fiber flax is carried on mostly in cool and humid regions. Practically all the fiber flax of the world is grown in Europe, where Russia is the principal producer. Here the bulk of the flax is raised in a belt which lies between the region of black and related soils of the south and the coniferous forest belt on the north

International trade in flax fiber is of relatively little importance. Much flax is still used for home consumption in Poland and Russia, but the best known centers of modern manufacture of linen are in Belgium, northern France, and the Belfast district of Ireland.

Selected References

Note: See "Selected References" at the end of Chapter XXVI for readings on the agricultural, animal, and forest industries of the intermediate climates

CHAPTER XXV

The Animal Industries of the Intermediate Climates

IN nearly all lands domestic animals play an essential role in agricultural activities This is true not only for agriculture as practiced in the more progressive countries, but also for the simple types of farming which still prevail in many parts of the world The peasants of southeast Asia depend upon the water buffalo for the preparation of their rice fields, and the negro farmers of the Sudan use the ox or the donkey wherever possible. Often the raising of domestic animals, even among primitive peoples, becomes an aim in itself. The negroes of the east African plateaus consider a large herd of cattle as a tremendous social asset, while in parts of the far north, for example in Lapland, the entire economic life of the people may revolve around the reindeer herd Domestic animals are often indispensable for purposes of transportation In the tropics, where good roads and railroads are few, domestic animals, though little used for other purposes, are essential as draft animals or as beasts of burden. In the great tropical desert areas the camel is still the principal carrier of freight and passengers, although in some regions the autobus and caterpillar truck are becoming serious competitors.

Notwithstanding their wide distribution and general importance, the animal industries are best developed in the regions of intermediate climates. Within these regions lie the principal areas which produce large surpluses of animal products, and here the horse, cow, pig, and sheep are of greatest importance in the agricultural scheme In the polar regions only the reindeer can survive, and in the tropical latitudes the animal industries are handicapped by the coarse grasses, deficient in

nutritive quality, and by the numerous animal pests and diseases which abound in the warm, humid environment.

HORSES

Domestic animals are kept for two major purposes. to provide men with food and material for clothing and to serve as sources of power. The horse is without a peer for the latter purpose, and therefore throughout the centuries it has been the principal beast of draft and burden available to man. Although originally animals of the semi-arid grasslands, because of their close association with tillage agriculture they are now most numerous in the regions of humid intermediate types of climate, especially in those of Europe and North America.

Distribution—The horse is not well adapted to warm climates, particularly to those of high humidity. Where environmental conditions are unfavorable for horses their role is often taken over by other animals, as, for example, in tropical India by cattle, in desert regions by camels, in the high mountains by llamas or yaks, and in polar areas by reindeers and dogs. Even in the subtropics horses do not flourish In southern United States and in the countries around the Mediterranean, mules and donkeys are more numerous than horses.

Because of their efficiency as draft animals, horses are essential to successful agriculture in the middle latitudes, and therefore most of the horses of the world are found in the humid intermediate regions of Europe and North America Horses have but slight importance as a source of meat or milk, except among a few nomadic peoples, such as the Kirghiz, where the milk plays an important role in the diet Since they enter but slightly into national or international trade, from the point of view of economic geography, they are of much less importance than cattle, swine, or sheep, whose products furnish a great variety of commercial commodities.

CATTLE

Two principal species comprise the bulk of the world's cattle, namely, the taurine cattle (Bos taurus) and the zebu or humpbacked cattle (Bos indicus). The latter do well in the

all-year warm climates. They are tolerant not only of high temperatures and great humidity, but, because of their ability to thrive on coarse forage, they are found also in areas of seasonal droughts While they are of little value as beef or milk producers, they make strong draft animals. Their resistance to disease is much greater than that of taurine cattle, a characteristic particularly important in tropical regions where parasitic insects and microörganisms flourish In southern United States, especially in parts of Texas, zebus have been crossed with taurine cattle The resulting breed has proved to be a fairly good beef animal which successfully resists ticks and which can subsist on coarse forage.

In the low, rice growing districts of southern Asia the water buffalo (Buffalo asiaticus) is the principal domestic animal It is thoroughly at home in a swampy environment, requires a daily bath, and likes to spend hours in the water, with only its head and horns protruding. The water buffalo is neither a good beef animal nor a good milk producer, but its great strength makes it valuable for the laborious process of preparing the wet rice fields.

The taurine group, which includes a great variety of breeds, is best adapted to areas where mild to cold winters alternate with cool to warm summers. Thus taurine cattle are found mainly in the middle latitudes and in the subtropics

Cattle raising.—In many parts of the intermediate regions, and particularly in Europe, cattle raising is not an aim in itself but is an integral part of tillage agriculture. The cattle consume those products which must be raised in the system of rotation, but which are unfit for direct human consumption, such as legumes and root crops. Their milk and meat are valuable farm products, while the fertility of the crop land is maintained partly with the aid of the animal manure.

Elsewhere, as in the River Plate region or in the American Corn Belt, the raising and fattening of cattle may be the principal aim of the farmer. In this case tillage agriculture is carried on mainly for the purpose of producing feedstuffs, such as corn and alfalfa

In still other regions, especially in the more humid sections of the semi-arid and arid lands, tillage agriculture is of little importance and the natural vegetation, which consists mostly of short grasses, provides the basis of an extensive type of cattle industry. In such areas summer droughts often compel either the use of supplementary feed grown on irrigated land or migratory movements of the herds from low, snow-free plains in winter to mountain pastures in summer.

The cattle industries of the tropics.—In the warm lands cattle are raised chiefly for local sustenance purposes, for power, meat, and milk British India outranks all other countries of the world in total cattle population, having about 180 000,000 cattle and water buffaloes, compared with about 60,000,000 in the United States The great majority belong to the humpbacked or zebu species. The bullocks are used as draft animals, the cows furnish a little milk, but in accordance with their religious beliefs the Hindus are forbidden to kill the cattle or to eat the meat As a result there is an appalling waste of animal products, since calves and cows which cannot be fed are allowed to perish

In the countries of the southern Far East, as far north as the valley of the Yangtze River in China, the zebu and the water buffalo are the only two types which can stand the climate In China the great density of population necessitates the fullest possible use of the land for the production of crops suitable for direct human consumption, and therefore but few cattle are kept, and those few are used mostly for draft purposes.

In Africa the principal cattle lands are the savannas and tropical steppes of the Sudan and the grasslands of the east African plateaus. The majority of the cattle there also belong to the humpbacked species. Among many negro tribes cattle are kept only for purposes of social prestige. Their milk is used extensively, but they are considered too precious to be eaten except on occasions of extraordinary importance. Over large areas of Africa, especially in the lowlands, stock raising is impossible on account of the prevalence of the dreaded tse-

tse fly, which is the bearer of sleeping sickness, a disease deadly to cattle as well as to man.

In tropical South America cattle raising is subject to the same difficulties as are encountered elsewhere in the warmer regions of the earth Animals of a rather inferior taurine type are produced extensively in the llanos or savannas of Venezuela and Colombia, but with indifferent economic success.

Cattle in the intermediate climates.—The principal centers of cattle production are found in the middle latitudes of Europe and North America, not including the areas of subpolar climate. Marginal to the areas of intermediate climate are the great cattle producing districts in Argentina, Uruguay, Brazil, the Union of South Africa, and New Zealand

In some of these regions cattle are raised primarily for beef, while in others milk and milk products are of chief importance. Both the beef and the dairy industries figure prominently in national as well as international trade

Among taurine cattle certain breeds are most valuable as meat producers, whereas others rank as better dairy animals. To the breeds preferred by the beef industry belong the Shorthorns, Aberdeen Angus, and Herefords, while the dairy industry is based largely upon the Frisian-Holsteins, Jerseys, and Guernseys.

The beef industry: *The United States.*—The raising of beef cattle is of great importance in the part of the Corn Belt which lies west of Chicago Large numbers of beef cattle are raised also on the farms and ranches in the Great Plains from Montana to Texas as well as in the valleys and on the mountain slopes to the westward In the Corn Belt not only are large numbers raised locally, but additional cattle are shipped in from the regions farther west. These so-called "feeders" are finished for the markets on corn. All through the Corn Belt feed lots are characteristic features of the farms, particularly near the great meat packing centers, which are, in the order of their importance, Chicago, Kansas City, Omaha, St. Paul, Sioux City, St Louis, and Fort Worth. These markets furnish

the bulk of the meat supplies for the densely populated industrial districts farther east. Exports of beef and beef products from the United States are not large, the trade with Hawaii, Puerto Rico, and Alaska surpassing that with foreign countries

South America.—In both Argentina and Uruguay the beef industry is a dominating factor in the economic life Originally the development of the cattle industry was favored by the enormous landholdings and by the nutritious grasses of the Pampa. The mild winters, which make grazing possible

Photo by R F Morgan, University of Nebraska

Fig. 269.—A typical feed lot on a mid-western farm. Hereford cattle at feed troughs, being finished for market.

throughout the year, proved to be an important asset At present the production of high grade beef in Argentina is to a large extent dependent upon the growing of alfalfa, which occupies an acreage only slightly smaller than that of wheat, and forms a valuable complement to the native grasses of the region On account of their small populations, Argentina and Uruguay have large surpluses of animal products Some of the low grade

beef, especially that from the neighboring Chaco, is made into meat extract and other products, but most of the beef prepared in the packing houses or "frigorificos" is high grade and is shipped in chilled or sometimes frozen condition to the great centers of consumption of western and southern Europe

Australia—In Australia the beef industry centers in the semi-arid prairies and savannas of Queensland, the Northern Territory, and northwestern Australia Density of cattle is greatest in the region of the so-called Queensland Downs. Australia is sparsely populated and so has a large surplus of animal products available for export. The country, however, is greatly handicapped by its distance from the principal centers of consumption in Europe Much of the meat is shipped frozen, because of the long voyage through the tropics, and brings appreciably lower prices than the chilled beef from the Plate River countries. New Zealand is also an important exporter of beef. There the cattle industry is concentrated primarily in the low coastal plains of the two islands.

Europe.—In most of Europe, north of the region of mediterranean climate, cattle are numerous, but, with the exception of parts of Great Britain and Ireland and of some lesser regions, the raising of beef cattle is not an aim in itself. it is an integral part of a highly diversified system of agriculture. Beef cattle are usually fattened by using locally produced grass, hay, or other roughage, supplemented by grains, oil cake, and other concentrates The latter are supplied only in part by local production, large quantities being imported. As a result of the dense population there are very few countries which consistently have an exportable surplus of beef On the whole Europe is an area of deficiency, in so far as meat supplies are concerned, and forms the principal market for all the meat-exporting countries of the world.

The dairy industry.—Beef cattle are relatively inefficient producers of food for human consumption. According to Gray and Baker[1] it takes 8 0 acres of crop land and 1.8 acres of humid

[1] Gray, L C, and Baker, O E "Land Utilization and the Farm Problem," *Miscellaneous Publication,* No 97, United States Department of Agriculture, Washington, D C, 1930

pasture or its semi-arid equivalent to produce a million calories of dressed beef. To produce the same amount of milk only 1 7 acres of crop land are necessary and approximately 1 15 acres of humid pasture or equivalent From these figures it is evident that generally the specialized raising of beef cattle can be successful only where population is sparse and land cheap. The British Isles form one of the few notable exceptions to this rule

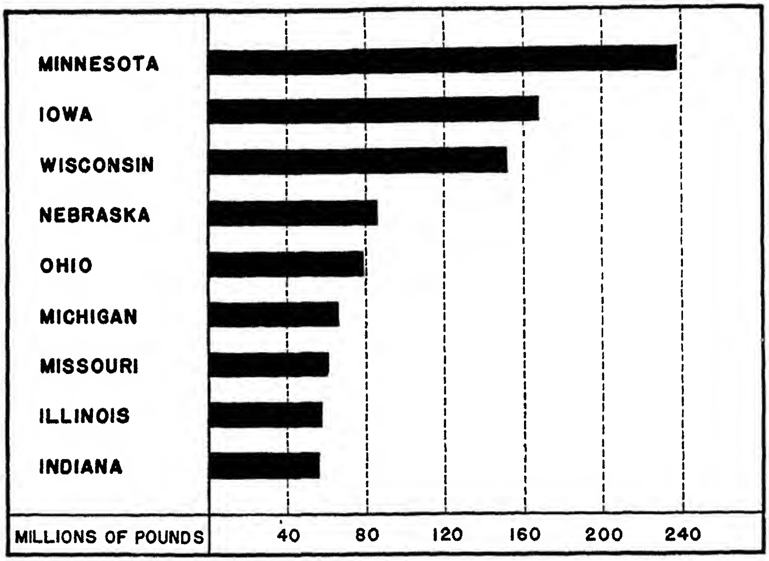


FIG. 270.—Production of creamery butter of principal butter producing states Average 1921-1930. (Source of data Yearbooks of the Department of Agriculture, Washington, D. C)

When the population is dense, land expensive, and the conditions of the natural environment favorable, dairying is the normal economic response It is also a successful pursuit in areas of relatively sparse population and high percentage of humid pasture land, where the latter is better suited for the production of feed and feed grains than it is for wheat and other foodstuffs

United States—In the United States the most favorable conditions for dairy farming are found in the so-called hay

and dairy region, which stretches from Minnesota through Michigan and eastern Ohio as far as Maine. Grass and hay are abundant, and all sorts of feedstuffs can easily be grown there. From the dairying standpoint this entire area is advantageously located near the industrial regions of eastern United States. While the states closest to the great urban centers, such as New York, New Jersey, and Massachusetts, devote most of their attention to the production of milk, in many instances

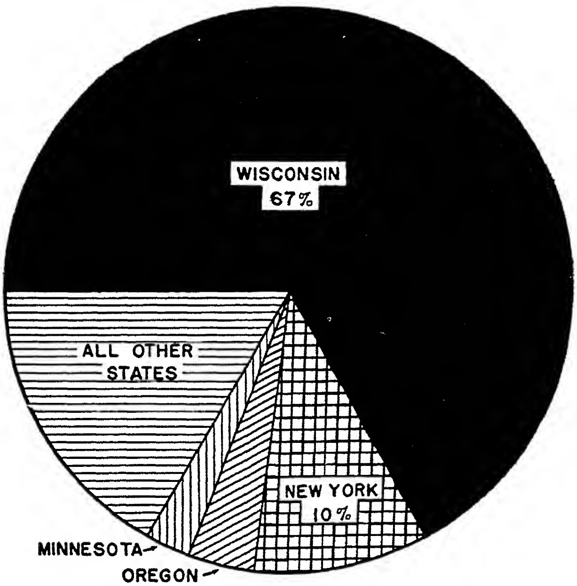


Fig. 271.—Production of cheese in principal producing states. Average 1922-1931. (Source of data: Yearbooks of the Department of Agriculture, Washington, D C)

shipped to the cities by special trains, the states farther west manufacture a large proportion of the milk into butter and cheese, both of which can stand some delay in shipment. The principal butter producing states are Minnesota, Iowa, Wisconsin, and Nebraska, and Wisconsin is conceded supremacy in the manufacture of cheese. Smaller dairying centers lie in the Puget Sound-Willamette Valley of Washington and Oregon, and in California. In the dairying regions of the northeast and in the Pacific Coast states much milk is canned in condensed

and evaporated form. Considerable quantities of canned milk are exported to Cuba, the Philippines, and other countries in Latin America and the Far East, which, on account of a tropical or subtropical climate, produce little milk themselves. The exports to Europe, especially to the United Kingdom, are also large.

Europe.—In Europe the dairy industry is highly developed, especially in the low-lying coastal areas from Brittany to southern Sweden and in the British Isles These regions are subject to the direct influence of the westerly winds, and thus have a mild and moist climate which fosters the growth of luxuriant grasses and the production of feedstuffs

The best known dairy districts are in Denmark and the Netherlands. In the latter the dairy industry is based primarily upon the succulent grasses of the "polders," the rich alluvial lands which generally lie below sea level The polders are surrounded by dikes, and the water table must be regulated by either steam or electric pumping plants, or by windmills Because of the large number of cattle per acre it is necessary to import supplementary feed, such as barley, linseed cake, and cottonseed cake or meal

The Danish dairy industry also is highly intensive It is dependent mainly upon feed crops, such as barley and artificial pastures of clover and hay Furthermore, large quantities of feedstuffs, especially concentrates, are imported from abroad

Other well known dairy districts are the plateau and the Alps of Switzerland and the Po Valley of Italy In Switzerland the high pastures above the timber line furnish excellent summer grazing for the mountain cattle The principal center of dairy production, however, lies on the plateau along the north foot of the Alps.

Denmark and the Netherlands rank first in the Northern Hemisphere as exporters of butter. The Netherlands is the largest exporter in the world of condensed and evaporated milk, while the principal cheese exporters in the order of their importance are the Netherlands, Italy, and Switzerland, all three of which are noted for the excellence of their product

New Zealand and Australia.—In recent years New Zealand and Australia have developed an extensive dairy industry and have become large exporters of butter. New Zealand also exports much cheese. In Australia the dairy industry is limited to the humid coastal districts to the south and east of the Australian mountains; in New Zealand the industry is carried on mainly in the coastal plains of the North Island. Besides the countries mentioned above, Canada exports considerable quantities of cheese and Argentina of butter.

SWINE

Swine are much better able to adapt themselves to different types of environment than are either horses or cattle. Some breeds of swine seem to flourish in regions with distinctly tropical climates, as, for example, in the Philippines and in some sections of Netherland India. Nevertheless, on a world map showing the distribution of swine, large areas will be found blank This is not the result of a lack of statistical data but of the prevalence of religious taboos. Neither Mohammedans, Hindus, nor Jews are allowed by the precepts of their religion to eat pork. Thus swine are scarce in British India in the Near East, and throughout most of northern and central Africa The principal swine raising regions are found in countries of intermediate climate, especially in North America and Europe, although important production is also found in southern Brazil and China.

Distribution.—In the United States the hog industry centers in the Corn Belt states, where it is due chiefly to the availability of corn as a feed, and where the raising of hogs forms the foundation upon which rests the entire agricultural scheme While much of the processing of hogs is done in the great packing centers mentioned in the discussion of the beef industry, considerable quantities of pork are dressed and manufactured in smaller packing centers scattered through the entire Corn Belt. In Iowa, for example, in addition to Sioux City, which has previously been mentioned (p 637), Waterloo, Cedar Rapids,

Mason City, Des Moines, and Davenport all have important packing industries.

In Europe swine are fed not only grains, especially barley and rye, but also potatoes and skimmed milk. Because of the latter the swine industry is often closely associated with the dairy industry, this being typically the case in Denmark and the Netherlands

The principal exporters of pork and pork products in the order of their importance are Denmark (bacon), the Netherlands (pork and bacon), the United States (ham, lard, and bacon) and Poland (lard and bacon).

It is in the form of lard, ham, and bacon that appreciable quantities of the corn produced in the United States are exported abroad By far the major part of these exports are shipped to Europe The trade with Latin American countries is important also, particularly that with Cuba, which ranks foremost among these countries as a consumer of American pork products.

SHEEP

Some breeds of sheep are excellent wool producers, for example, the Merinos and Rambouillets, while others, such as the Lincolns and Shropshires, are primarily meat producers Furthermore, in recent decades a large number of cross breeds have been developed which are satisfactory for the production of both meat and wool.

Since sheep can subsist and often flourish on rather coarse feed not relished by other domestic animals, most of the sheep of the world are raised in regions which must be considered marginal for other agricultural purposes; i e , areas which are either too dry, too stony, or too mountainous for farming. Sheep were often the mainstay of the pioneer, because they could easily be herded and the wool could stand the high costs of primitive transportation facilities or of transportation over long distances

The principal sheep raising regions of importance from a commercial point of view are Australia, the River Plate region,

the Union of South Africa, and New Zealand, all of relatively sparse population, and of extensive areas of humid to semi-arid pasture. In the most humid districts the mutton types predominate In the dry lands, as in most of Patagonia, in interior Australia, and on the high plateaus of South Africa, the wool producing breeds are in the majority.

Courtesy, Official Secretary for Australia in U S A, New York

Fig. 272.—Transportation of wool, New South Wales, Australia

Sheep in the United States.—In the United States sheep are most numerous in the semi-arid and mountainous range country west of the Great Plains, on the Edwards Plateau of Texas, and in Ohio and parts of neighboring states While formerly sheep of the wool-producing Merino and Rambouillet types predominated in the United States, at present an ever increasing percentage is raised primarily for meat, and even on the western ranges production for both meat and wool is favored In the semi-arid ranching country of the west, sheep raising gives rise to regular migratory movements: from the winter grazing grounds in the desert areas to the high summer pastures, most of which lie in the National Forests Production

of early lambs is important in many parts of the ranching area The principal fattening and finishing districts for lambs are the valleys of the North and South Platte Rivers in Colorado, Wyoming, and Nebraska, the Snake River district of Idaho and Washington, and the valley of California The latter produces winter lambs

In the Corn Belt and the states farther east, sheep are less numerous and are bred mostly for mutton and the production of lambs In western New York, central Ohio, and southern Michigan, "hot house" lambs have become an important source of income to the farmer. On the hilly lands of southeastern

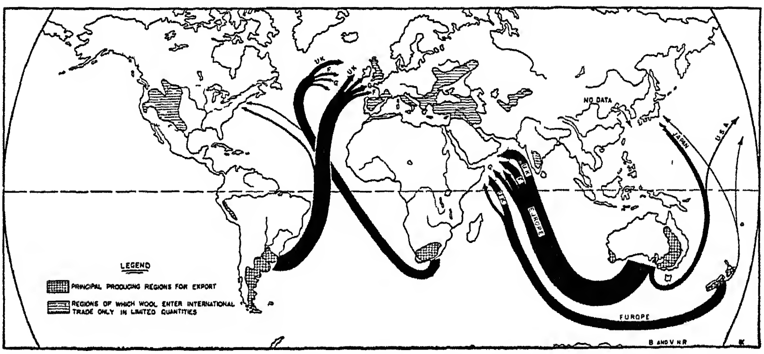


Fig. 273.—Principal wool producing regions of the world, and trade in wool.

Ohio, fine wool sheep mostly of the Merino type are bred extensively.

In the mountainous districts of southeastern Europe, sheep do well on lands poorly suited to tillage agriculture However, none of the countries of this part of Europe have an appreciable export surplus of either wool or meat

In western Europe, Great Britain has an exceptionally large number of sheep This is due in part to the large extent of poor grazing country, in part to the popularity of mutton in the British diet. On account of the dense population, however, there is a large deficiency of both meat and wool

International trade in sheep.—The large exporting countries of wool and mutton all lie in the Southern Hemisphere:

the Plate River countries, South Africa, Australia, and New Zealand The exports of mutton are mostly destined for the British Isles The wool is exported to the countries which are important centers of manufacture of woolen goods, principally the United Kingdom, the United States, France, Germany, Belgium, Italy, and Czechoslovakia. The Leeds-Bradford district in England is the leading woolen manufacturing district of the world.

Selected References

Note: See "Selected References" at the end of Chapter XXVI for readings on the agricultural, animal, and forest industries of the intermediate climates

CHAPTER XXVI

Forests and Forest Industries of the Intermediate Climates

THE great forest areas of the world lie in the humid tropics and in the humid parts of the intermediate climatic regions. While in the former the forest cover is still largely intact, in the latter man has profoundly altered the natural landscape in his quest for lumber and tillable land.

FORESTS

In those portions of the intermediate regions which are most favorable for agricultural development, the once extensive forests of deciduous hardwoods, and of mixed hardwoods and conifers, have generally succumbed to the axe of the woodman and the farmer. Even some of the marginal regions not well suited for agricultural purposes have been denuded of their stands of virgin timber The most extensive deforested areas of the world lie in the middle latitude zone of northern China, in Europe south of the 60th parallel and as far east as the Ural Mountains, and in the United States east of the Mississippi In these areas a cultural landscape consisting of tilled fields and pasture lands with scattered stands of second growth timber has supplanted the original continuous forest cover Only in mountainous regions poorly adapted to agriculture has the forest been able to maintain itself But little virgin timber, however, is left in these regions, and in many countries, especially in western and central Europe, these remaining forest resources are carefully husbanded and so managed that sustained yields seem assured

The northern coniferous forests.—Farther poleward, where short growing seasons and poor soils hamper agricultural de-

velopment but allow the growth of hardy conifers, the forest still dominates the landscape. There an immense belt of coniferous forests, which roughly coincides with the belt of sub-Arctic climate, stretches across northern Eurasia and North America, projecting far southward along the slopes of the mountains in western United States The only other important areas are those of southeastern United States and the Parana pine forests of southern Brazil.

Southward, the forests of the sub-Arctic belt merge and mix with the deciduous forests of the milder intermediate climates, conifers usually occupy the poorer soils and the higher lands where growing seasons are very short. Northward, toward the Arctic tundra the stands gradually become less dense and the trees smaller, until only a few low and deformed individuals survive in the most sheltered places Thus, from a commercial point of view the southern half of the sub-Arctic forest belt is of the greater importance

The forests consist mainly of a relatively few types of coniferous or softwood trees, which generally appear in pure stands, this being markedly true of the pines and spruces[1] The more tolerant types of hardwoods occur also, especially near the southern margin of the coniferous forests, although some species of birch and poplar extend far north. The latter often flourish where forest fires or indiscriminate cutting have destroyed the stands of conifers. In Canada, for example, large areas are occupied by aspen, a species of poplar

Not all of the sub-Arctic belt is, however, covered by forest vegetation Northern Eurasia and northern North America both were heavily glaciated during the Ice Age. This resulted not only in poor, stony soils, but also in poor drainage Although the annual precipitation is small, evaporation is retarded by the prevailing low temperatures, and therefore much water is available for runoff. On account, however, of the highly irregular glacial topography much of the surface runoff collects

[1] The principal trees of the northern coniferous forests are pine (Pinus), spruce (Picea), fir (Abios and Pseudotsuga), tamarack (Laris), hemlock (Tsuga), and cedar (Thuja).

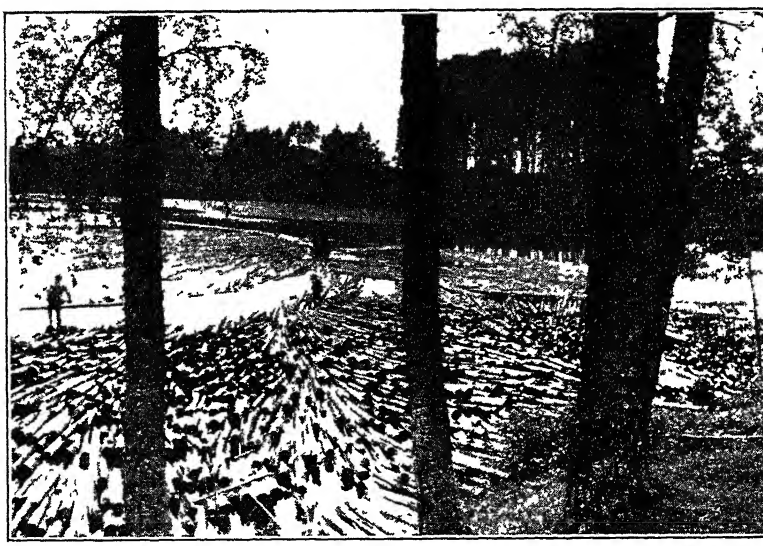
in numerous swamps and peatbogs On these, tree growth is either absent or badly stunted, and such timber as exists is useless for commercial purposes Thus, of the approximately 2,300,000,000 acres of forest land in Soviet Russia, nearly 800,000,000 are estimated as consisting of worthless swamp and bog lands, the bulk of which are located in the sub-Arctic belt In Siberia only 56 per cent of the forest area is considered actually to be forested It is estimated that peatbogs devoid of merchantable timber account for 30 per cent of the total area of northern Sweden In the northern coniferous area of Canada similar conditions exist

Lumbering.—The lumber industry of the sub-Arctic belt is carried on in a stern natural environment In most of these regions population is sparse, and agriculture often can survive only in close association with the exploitation of the forests However, some of the factors which handicap agricultural development are among the most valuable assets of the lumber industry, as, for example, the snow cover during the long cold winters and the spring freshets of the numerous rivers

Cutting generally begins early in the fall, before the snow has become too deep Where agricultural communities exist in close proximity to the exploitations, as in Sweden, Finland, and Quebec, the farmer becomes a lumberjack for the winter season Elsewhere, as in parts of Canada and northeastern European Russia, the labor must be imported. The snow facilitates dragging the logs to the streams by horses or tractors. They are piled on the ice, and in the spring, when the melting of the ice and snow causes a brief period of high water, they are allowed to float down the rivers to where they can be sorted as to ownership and size, then processed in either sawmill or pulp factory

In some regions, particularly in Sweden, large amounts of capital have been invested in the improvement of these log "driving" ways, by eliminating rapids and shoals, by anchoring rows of floating logs along the banks and in the bends of the streams, and by the construction of flumes and other devices to secure a most efficient use of the spring freshets In northern Russia log driving is handicapped because the majority of

the rivers flow northward into the Arctic Ocean, and therefore the ice breaks up in the upper courses long before it does farther downstream. The floods which result may scatter the logs over the entire width of a valley On the Pacific Coast of North America much of the timber is too large, and most of the streams are too swift and contain too many falls and rapids, to make possible the use of this cheap method of transportation. Consequently, mechanical means of transportation must be



Courtesy, Swedish Chamber of Commerce of the U S A, New York

Fig. 274.—Log driving on a river in northern Sweden

used In most districts railroad systems which include narrow gauge "feeders" and standard gauge main lines have been built to transport the lumber to the coast With such equipment lumbering may be carried on throughout the year

Principal centers of forest exploitation.—The lumber industry is carried on mainly in accessible areas which are relatively close to markets In Eurasia the principal centers of production for lumber and pulpwood are found in northern Sweden, Finland, and northern European Russia, especially the respective hinterlands of Leningrad and Archangel. In Canada

the provinces of Quebec, Ontario, and British Columbia have the largest annual timber cut

Large parts of the northern coniferous forest belt, especially in Siberia and in western interior Canada, are so far from the areas of consumption and have such poor transportation facilities that at present commercial exploitation is impossible.

Timber resources and forest exploitation in the United States.—In the United States the original immense resources of hardwoods and softwoods have been greatly depleted, partly

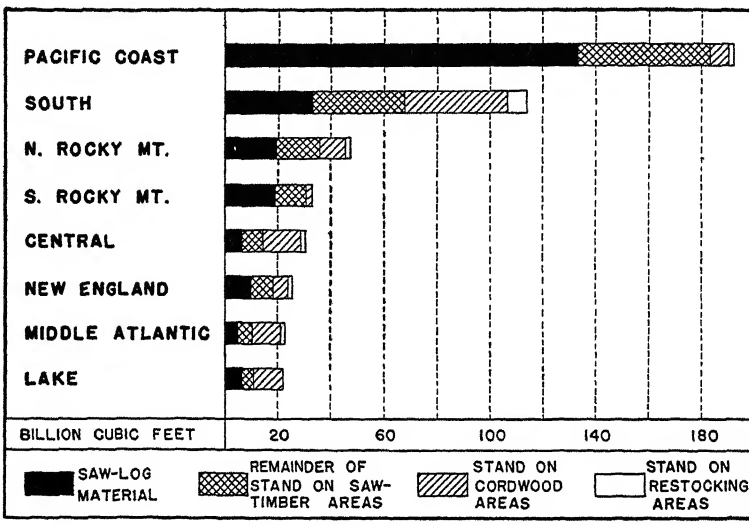


FIG. 275.—Total stands of timber in the forest regions of the United States. (Source *Senate Document No 12,* Seventy-third Congress, First Session, Washington, D C, 1933)

because vast areas have been cleared for agricultural use, partly because much land unsuitable for agriculture was so completely stripped of trees by the lumber industry that restocking by natural means became an exceedingly slow process In the areas of coniferous forests, especially, what was left by the lumberman in many instances was destroyed by fire, and so low grade hardwoods subsequently took the place of the valuable softwoods It is estimated that of the original stands in the United States hardly one-fourth is left today, and that mostly softwoods The only area where considerable stands of virgin

hardwoods still exist is the lower Mississippi Valley. The coniferous forests of New England and of the northern sections of the Lake states are greatly depleted, and at present they contribute less than nine per cent of the total amount of softwood produced in the United States. The bulk of the merchantable timber left in this country is found in the Pacific Coast states, on the slopes of the Cascades, the Sierra Nevada, and the coastal ranges of Washington and Oregon

These forests consist almost entirely of coniferous trees, among which the Douglas fir (Pseudotsuga taxifolia) and the western yellow pine (Pinus ponderosa) are of major importance The Pacific states are responsible for more than one-third of the entire softwood production of the United States.

As a producer of both softwoods and hardwoods, southern United States still holds first place. The area occupied by commercial forest land in the South is estimated at 190,000 000 acres, or nearly 40 per cent of the total for the United States. Of these only 14,000,000 acres bear virgin saw timber, the remainder consisting of second growth saw timber, cordwood, and cutover areas The stands available for commercial purposes are less than 60 per cent of those in the Pacific states, those of saw timber less than 25 per cent. Nevertheless, the southern states account for nearly half of the total production of softwood and for nearly two-fifths of the total hardwood production of the United States. This is a heavy drain on the resources, and signifies that in the near future the lumber industry will have to fall back upon the last available reserve, the forests of the Pacific Coast, which fortunately still are largely in the hands of the Federal Government As the virgin stands are nearing exhaustion, it is now advisable and soon will become necessary to adopt policies of scientific forest management, similar to those practiced in Europe and on some of the national forest lands, in order to procure a dependable supply of timber.

World lumber trade.—The bulk of the timber which is cut in the middle latitudes is used for lumber and fuel. In the majority of the countries which are located in the intermediate climatic regions, consumption exceeds production and large im-

ports are necessary The principal exporters are those countries which have a share of the great sub-Arctic belt of coniferous forests: Canada, Sweden, Finland, and Russia The United States, although importing annually from one to two billion board feet for various purposes, in normal years exports from two to three billion board feet

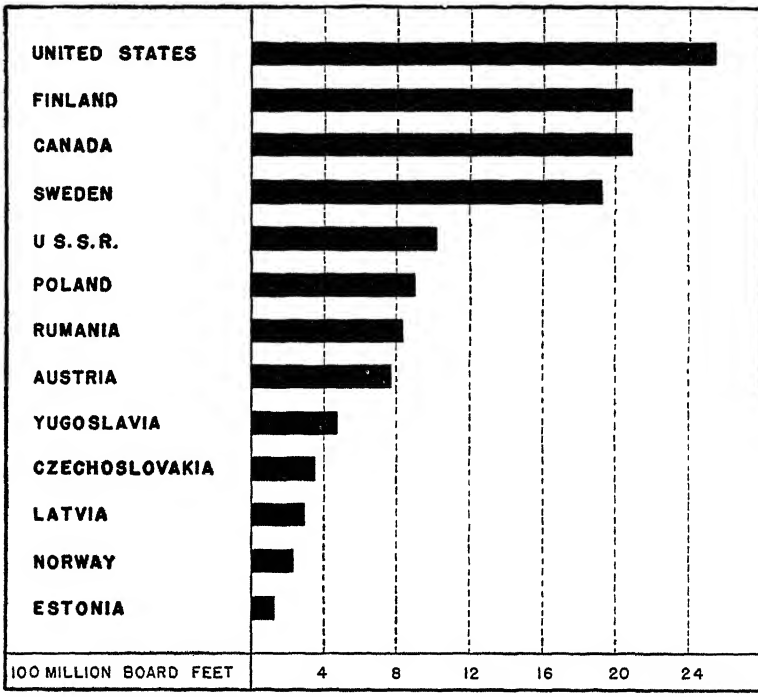


Fig 276.—Exports of soft wood lumber from principal countries. Average 1925-1929. (Source *Senate Document No 12,* Seventy-third Congress, First Session, Washington, D C, 1933)

While in the past most of the lumber entered world trade as roughly hewn logs, now it is generally shipped as lumber. Some producers export even semi-manufactured and finished products, such as plywood, roof shingles, doors, and window frames

WOOD PULP AND PAPER

During the last half century the paper industry has become an important consumer of timber, since most of the paper used

in the world is now made of wood fiber. In response to the greatly increased output of books, magazines, and especially of newspapers, the requirements of the paper industry have grown enormously. For the manufacture of paper stock soft, resin-free coniferous woods are preferred, especially spruce and hemlock, although in recent years considerable quantities of aspen and yellow poplar have also begun to be used Since the size of the timber is not an important factor, the paper industry can absorb large quantities of wood which are not suitable for saw lumber purposes.

The wood is reduced to pulp either by purely mechanical means or by cooking under steam pressure and with an admixture of chemicals All of the newsprint and other cheap grades of paper, which do not need to be of great strength nor of pure white color, are manufactured from mechanical pulp The chemical processes eliminate a large part of the lignin or wood substance, leaving mostly cellulose. They are more expensive than the mechanical processes and yield smaller amounts of pulp, which is, however, of longer fiber and can more easily be bleached. The sulphite process, which consumes especially spruce and hemlock, is used for the finer grades of paper, as for example book paper; the sulphate process is employed for the production of brown wrapping or Kraft papers; the soda process is applied to hardwoods, as aspen and yellow poplar. Soda pulp is generally mixed with sulphite pulp for the production of low and medium grade papers In the United States mechanical and sulphite pulp constitute two-thirds of the total requirements

Pulp production.—The pulp industry depends not only upon large amounts of cheap woods, but also upon the availability of cheap power. Thus, the industry is located mainly along the southern edge of the coniferous forest belt in America, and along the coasts of Sweden and Finland, where raw material is abundant and where waterpower can often be easily developed because of the glacial topography The principal producers of wood pulp are the United States and Canada, Sweden, Finland, Norway, and Germany In the United States the

majority of the pulp factories are located in Maine, Wisconsin, and New York Because of the depletion of the local resources, huge quantities of pulpwood and wood pulp have to be imported annually from Canada and the Scandinavian countries. In recent years a pulp industry has begun to develop on the Pacific Coast, while in the South considerable quantities of pulp are produced mostly for the manufacture of Kraft paper. In Canada the provinces of Quebec and Ontario rank first as pulp and paper producers, but the industry has also established itself on the west coast, near the immense forests of British Columbia

Among other important industries which consume appreciable quantities of wood must be mentioned the wallboard, rayon, and cellophane industries.

While large quantities of wood are still available both in the more and in the less accessible parts of the sub-Arctic softwood belt, the rapid depletion of the virgin stands in several regions will make it urgently necessary to inaugurate a policy of forest conservation such as is now practiced in Sweden and Finland, not only because the wood consumption of the world may yet increase, but also since on most of the land under coniferous forest, timber is the only profitable crop.

FURS

The coniferous forests of the northern sub-Arctic belt are the abode of numerous fur-bearing animals, varying in size from weasel to bear. The hunting and trapping of these animals provide a welcome source of cash income in many regions where returns from agriculture are small, and farther poleward they develop into an industry to which the population may devote most of its time

The longer and colder the winters are, the better generally is the quality of the fur. Inasmuch as agricultural settlement with its attendant depletion of wild life has penetrated but slightly into the southern fringe of the great northern coniferous forests, they still harbor large numbers of valuable fur animals, as fox, weasel, sable, mink, muskrat, and beaver.

The small bulk and high value of most furs are sufficient to

mostly to a policy of conservation of wild life adopted by the states, the total catch of fur animals is still estimated at from 40 to 70 million dollars per year Among the fur producing districts, the lower Mississippi basin ranks high, while considerable numbers of fur animals are also trapped in the coniferous forest regions of northern United States St. Louis is a large fur collecting center, and New York City ranks with London and Leipzig as a great world market

Fur farming.—As a result of the gradual retreat of wild life before the advance of white man, and the increasing popularity of fur clothing, it has become profitable to raise certain kinds of fur animals, especially silver fox Fur farming is practiced extensively in northern United States from New England to the Pacific Coast. In southern Canada also, especially in the Maritime Provinces and Ontario, it has become a major industry It is estimated that pelts of animals raised on farms comprise nearly 20 per cent of the total value of the Canadian production. The practice has likewise been introduced successfully into several European countries, notably Norway and Germany.

Rabbits are raised in many countries, both for skins and for meat The skins, which by various processes of manufacture can be made to resemble more expensive furs, play an important role in the international fur trade, Australia being the foremost exporter of this commodity

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CHAPTER XXVII

The Polar Climates

BEYOND the middle latitudes lie the realms of winter, where ice and snow grip not only the land, but also the vast expanses of the ocean. The polar climates reign where freezing temperatures occur in all months of the year, and where the average temperature even of the warmest month remains below 50°F The summers, though occasionally bringing warm days, are of such short duration that their effects are entirely overshadowed by those of the long unbroken winter. The bleakness betokened by ice and snow is the predominant aspect of the landscape.

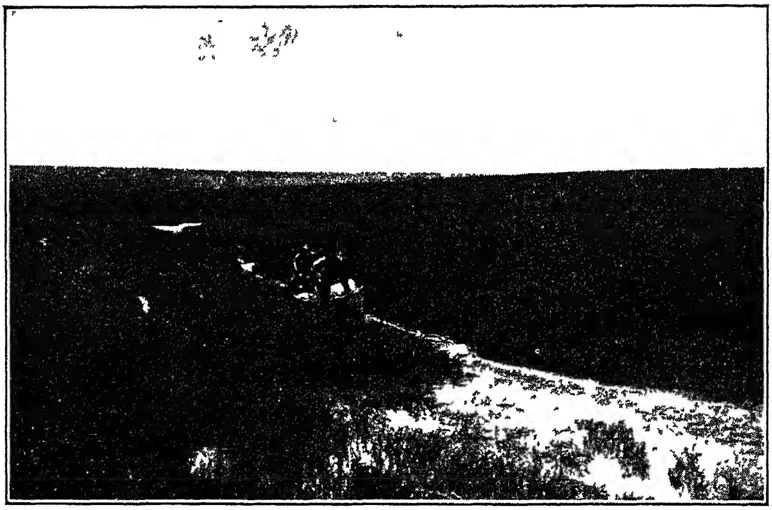
Even along the warmer margins of regions having polar climates the prevailing low temperatures prevent the growth of tall trees. Although during the brief summer the upper soil may thaw out to a depth of one to three feet, the subsoil remains frozen throughout the year Most of the precipitation falls as snow and, measured in inches of water, is so small that the polar regions would be distinctly semi-arid if the temperatures were higher Two principal types of climate can be recognized. the one characterized by a short summer which makes possible the growth of a low, shrub-like vegetation, is known as the *tundra,* and the other; the *ice cap* type prevails where the ground is never free of snow and ice, and the higher forms of vegetation are entirely absent

THE TUNDRA

The tundra is extensive in the Northern Hemisphere, but in the Antarctic is limited to a few small islands scattered through the southernmost part of the oceans.

The term "tundra" is derived from the Finnish *tunturi,* which

means a flat, barren plateau In usage the meaning of the word has gradually broadened to embrace the treeless, steppe-like areas covered with a vegetation of mosses and scanty grasses and sometimes of low shrubs, which are so characteristic of the far north, and even to designate the climate typical of these regions As here used, the tundra includes all areas where the average temperature of the warmest month is below 50°F, but above freezing point (32°F.). It forms a belt of varying width which surrounds the Arctic Ocean, stretching over nearly ten



Courtesy, Alaskan Branch, U S Geological Survey

Fig 277.—Tundra in Alaska. Note swampy conditions and boat being towed along small channel. Men wearing mosquito nets to protect themselves from insects.

degrees of latitude in the Taimir Peninsula and in extreme northeastern Asia. The total land area included is vast, being variously estimated at three to five million square miles The edges of the tundra are lobate along the southern border, projecting far southward on upland areas and receding northward in the major stream valleys In North America the tundra extends from northern Alaska to northern Labrador, including the so-called Barren Grounds of Canada.

Climatic conditions.—Winter, the dominant season, is a period of darkness as well as of cold. In the southern parts the

sun shines but two or three hours a day during midwinter, and in the northern parts it does not appear above the horizon for several weeks. Temperatures of -40°F are common, and often they fall still lower The snowfall, though not heavy, blankets the frozen ground On the other hand, summers are short, featured by almost continuous sunlight, and in some of the more

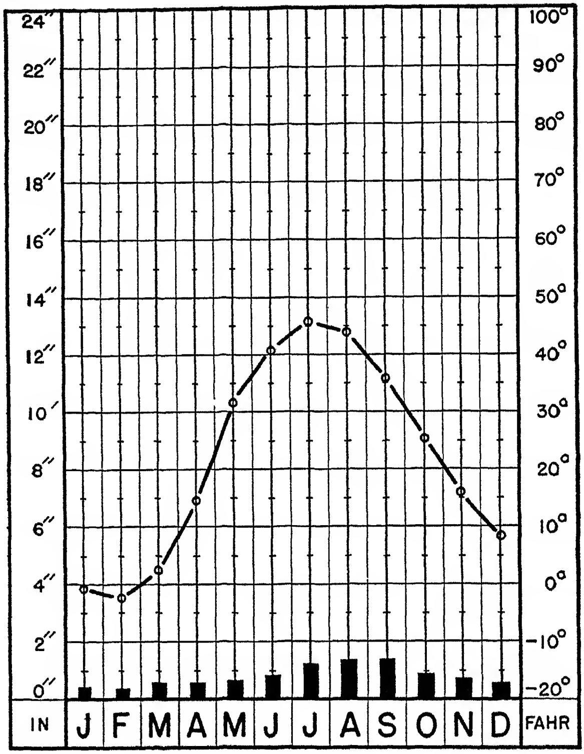


Fig. 278.—Tundra climate. Average temperature and precipitation, Jacobshavn, Greenland. Altitude 40 feet, total precipitation 9 inches

continental areas temperatures mount to unexpected heights. Summer maxima above 80°F often occur where in winter the temperatures drop to -60°F or lower. Even greater extremes occur in some places, as, for example, at Fort Good Hope in northern Canada, where summer maxima of 95°F and winter minima of -79°F have been recorded Spring may not come until June, and then only as a brief transition period from win-

ter cold to summer warmth Autumn is an equally short period, in late August or early September, when the warmth and flowers of summer are displaced by cold blasts introducing the long winter

Most of the precipitation falls as rain or snow in summer or early autumn, when temperatures are generally well above the freezing point. Although not heavy, often averaging less than 10 inches during the year, most of the rainfall becomes soil moisture because of the flatness of the tundra lands and the low rate of evaporation. The relative humidity is high, 70 per cent or more, during much of the summer, and thick fogs are characteristic of the early part of this season in most of the coastal areas and often far inland.

The long summer days, with continuous sunshine for weeks, as is the case from latitude 68° northward, constitute a period of weather which people of lower latitudes usually do not associate with polar climates. Sunshine uninterrupted except by occasional clouds, temperatures warm enough to be pleasant, a landscape verdure-clad and in some of the more favorable spots flower-bedecked, characterize the midsummer weeks. But this season is of short duration, so short, in fact, that at its height people who live there begrudge themselves the time for sleep. And then the long polar winter comes. Although the winter is a period of intense cold, of raging storms, and of great hardships for man, it is not without its compensating features Along the southern margins brilliant moonlight at times dispels the darkness of the sunless days. At that season, also, the aurora reaches its maximum of brilliancy. At times, on crystal-clear nights, the whole sky is covered with surging waves of color; bands of green and blue and purple and pink go shooting, rolling, twisting across the heavens in a display of changing brightness never the same for two successive seconds Only in the high latitudes can one find such superb celestial beauty.

Resources.—The known resources are based on the natural vegetation The tundra is the land of the reindeer and the musk ox, and during the warm season the home of myriads of birds

and insects The bordering seas are the habitat of the seal, the walrus, the whale, and many kinds of fish. The human economy is based entirely upon the utilization of animal life, because no tillage agriculture is possible

With the passing of the winter snows, vegetation surges into life as though to make the most of the short summer season Where the snow cover serves as a protecting blanket against intense cold the vegetation is fairly profuse, while windswept places support but sparse growths In swampy areas, caused by frozen subsoil and inadequate surface drainage, water-saturated spongy mosses abound; in the drier places various kinds of lichens, as the reindeer moss, cover the ground and even grow on the surfaces of naked rock In some of the more sheltered and better drained lowland areas occur the arctic "prairies," consisting of a herbaceous vegetation of biennials and of scattered grasses and shrubs usually less than knee-high During the brief summers these "prairies" form oasis-like spots where brilliantly colored flowers abound.

The drier parts of the tundra are capable of serving as grazing grounds for large numbers of meat animals, such as the reindeer, the caribou, and the musk ox.

Human activities.—The human population of the tundras is sparse. These regions are at the poleward limits of the higher forms of life, and the struggle for existence is intense and hazardous The best known groups of people are the Eskimos of North America and the Lapps and Samoyeds of Eurasia

The people of the tundra have been stamped by the stern environment in which they live; although belonging to various racial groups, their material cultures and modes of living are strikingly similar. Such differences as exist are largely a result of the differences in degree to which the people depend upon the resources of the Arctic Sea. Most of the inhabitants of Eurasia are inland dwellers; in the autumn they withdraw to the forest, where they can find shelter to protect their herds from the blizzards There they also add berries and nuts to their diet of meat. Their mainstay of economic life is the reindeer, domesticated because it could use the tundra forage and

provide man with materials for food, clothing, and shelter, and thus serve as a means of subsistence The Lapps and the Siberian peoples of the tundra are nomadic; they live in tents throughout the year, only a few tribes having more permanent habitations Their migrations and mode of life are adjusted to the requirements of their herds, and these in turn are in accord with the nature of the country. Since the most extensive pastures, those of reindeer moss, grow slowly and require several years to recover from overgrazing, the herds must continually be kept moving In winter these peoples migrate southward, in summer northward, seasonally seeking the areas where forage is most readily accessible and, so far as possible, avoiding storms and insect enemies

The Eskimos, generally coastal dwellers, depend more directly upon the sea They have become skillful hunters and fishermen They are recognized as being among the most adept people in the world in handling canoes, their particular kind of canoe being known as a *kyak*. In west Greenland the Eskimos have become distinctly sedentary, but in the northern part of Canada most of them retain their nomadic tendencies There in winter they concentrate in larger settlements, while for the summer hunting they disperse over wide areas.

Economic significance of the tundra.—Although not equalling the subpolar regions, the tundra has long been of some importance as a source of fine furs Thousands of sable and blue fox furs are marketed every year from these areas of Canada and Siberia It is said that because of his contacts with American fur traders the Eskimo thinks of the white man's world as one of big boats, soap, warm water, and odd looking footgear, and that white men spend almost all of their time looking for skins. So long has he trapped and brought his pelts in for trade, and so long has he been exhorted to hurry back with more, that he has come to think of the arctic skins as a sort of hub around which the wheel of civilization moves.

As a resource subject to exploitation in the distant future, the tundra pastureland must be given high rank. Several million square miles are available for reindeer grazing. Since these

animals survive without feeding or prepared shelter, the production costs are low Reindeer meat from Alaska already reaches the table in New York City, and restaurants in London and Berlin occasionally serve reindeer meat from the northern sections of Eurasia While there is little prospect of the industry becoming a great commercial significance in the near future, as a possible source of meat supply later on it promises well The human population of the world is continually increasing, a trend that has not been interrupted for decades. The pressure upon the land to produce the necessities of life is gradually becoming greater. If these trends continue, it is inevit-

Photo by Miss Faye Cypher

Fig. 279.—Herd of reindeer in the tundra near Flat, Alaska.

able that eventually cultivable lands must be used for crop agriculture and that grazing lands will become of increasing importance for meat animals In that distant future the tundra regions may become recognized as the world's most extensive pasture lands

THE ICE CAP TYPE OF CLIMATE

In the ice cap type of climate all-year cold reigns supreme. The average temperature of the warmest month is below 32°F. Statistical data concerning climatic details are fragmentary, because no permanent meteorological stations have been established in these climatically hostile regions

The ice cap climate dominates interior Greenland, the Arctic Ocean, and Antarctica These regions have long challenged the imagination and adventurous spirit of man Associated with them are the names of a host of men, fearless of the hazards of the unknown Among those whose exploits have been truly heroic are Franklin, Greely, Nordenskjöld, Nansen, Scott, Shackleton Peary, Amundsen, Wilkins, and Byrd. Many other names merit a place in any honor list, but the above mentioned are outstanding

The question is often raised as to why men undergo the hardships of polar exploration and face its dangers "Cold hostile deserts" is a term which epitomizes the ice cap regions, because there is virtually no life, neither plant nor animal While lands for settlement cannot be expected as a reward for new discoveries and explorations in the polar regions, and perhaps other economic rewards likewise are remote, exploratory efforts are justified because their achievements push back the veil of ignorance Man seeks to know the world, all parts of it, regardless of economic benefits Knowledge is worth while for its own sake, and that ideal has been dominant in nearly all polar expeditions. Since aviation has become recognized as a practical means of trade and transportation possibilities, interest in the north polar areas has loomed large because of their location in respect to potential air routes, and thus has been added an economic motive to the zeal of explorers

In recent years scientific thought has been directed to the polar regions because of their possible influence upon world weather Many scientists believe that if we knew more about the meteorological conditions in polar areas we would have added evidence upon which to interpret the weather of the middle latitudes It is thought that a knowledge of the sequences of weather conditions over the polar ice caps might afford a fairly reliable basis for making seasonal forecasts regarding the weather which would be likely to prevail during the succeeding weeks or months over the agricultural lands within the intermediate climates These are some of the problems which await solution, and it is possible that further knowledge of conditions

within the polar regions will be of practical value In view of the varied interests of adventure, of air navigation, and of meteorological research, the polar regions bid fair to remain in the limelight of exploration for years to come The poles have been reached, but vast areas still unseen serve as a challenge to the zeal to know, a zeal which constitutes one of the finest attributes of man.

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CHAPTER XXVIII

The Economic Significance of the Sea

MORE gold is tossed about, by the waves of the ocean than is possessed by man This truth, however, is not of economic significance at present, for the cost of obtaining the gold is prohibitive. Similarly, while more energy is contained in the movements of the tides than is now utilized in all of man's industrial plants, this potential power is of little economic significance because machinery for its extensive utilization has not yet been devised. Concealed within the ocean depths are many other resources of potential value to man which, although now largely latent, may some day help to make a better and more prosperous world

There are yet other values of the sea that are beyond the reach of the statistician Throughout geological ages the seas have aided in the construction of vast areas of sedimentary rocks, areas which after uplift and surface changes now constitute large parts of the continents. Interbedded with these sedimentary rocks are great stores of coal and petroleum—products without which the modern industrial civilization would not be possible.

The climatic influence of the sea is another factor to which the yardstick of pecuniary value cannot be applied. The seas serve as a vast primary reservoir from which the air derives the supply of moisture which is essential to all life on the continents. They serve also as a great regulator of temperature by absorbing heat and thus exerting a cooling influence on the air above, or by radiating heat and thus warming it.

Another economic role of the sea, the value of which can hardly be measured, is its use as a highway of transportation. The ocean is a roadbed against which there are no charges for

construction, maintenance, or taxes Open to most nations and touching all shores, it has always appealed to the adventurous spirit of man, has induced exploration, and has facilitated international trade.

It seems reasonable to assume that primitive man hunted before he engaged in agriculture Inasmuch as weapons with which to subdue animals were devised slowly, man's earliest activity probably was that of gathering low forms of animal life along the shore. Thus, from the earliest times to the present, the fisheries of the sea have contributed valuable products to the economic scheme of man.

To millions of people in the tropics, particularly to those in the rice-consuming countries of the Far East, fish rather than meat provides the necessary proteins in the diet. Along many of the rugged coasts of western Europe, where but little land is fit for agriculture, fishing is the principal industry, this being especially noteworthy in the case of Norway, Brittany, and northern Scotland England, deficient in products of the farm, secures a catch which provides for an average annual consumption of fish in excess of 40 pounds per capita.

Americans eat less fish than do most Europeans. As an adjunct to the regular meat diet, however, the value of fish is greater than is indicated by its measure in dollars and cents. Products of the sea are rich in essential mineral salts, and especially so in vitamin D and iodine, and thus they serve a useful purpose in providing a varied and wholesome diet

The nature of marine life.—As a result of diverse environmental features, some parts of the land areas of the world support abundant plant and animal life, whereas in other parts such life is sparse The oceans similarly provide diverse environments, although the contrasts are not so great as on land The old adage that the seas are barren wastes has of course but a small element of truth Conversely, the more recent saying that the sea is a rolling meadow, teeming with life, is equally absurd Broadly speaking, the ocean as well as the land has its rich pastures and its barren deserts. In the sea, as in and on the land, are flora and fauna of widely varied kinds There are

micro-organisms and macro-organisms belonging to the plant and animal kingdoms, and of each there are almost innumerable species

Phyto-plankton or plankton plants.—Inasmuch as all animal life, directly or indirectly, is dependent upon plant life, quite naturally it thrives best where the latter is abundant. Of the marine plants, the simple-structured, floating kinds, collectively known as *phyto-plankton,* or *plankton plants,* are fundamental in supporting water animals[1] Only plants possess the ability to convert inorganic material into organic matter, and since sunlight is the source of energy by means of which they must accomplish this conversion, marine plant life is limited to such depths as may be penetrated by the sun's rays, which is about 600 feet Beyond this depth life forms are fewer and consist predominantly of animals which feed on organisms descending in dead or dying condition from the waters nearer the surface

The oceans cover about 139,000,000 square miles of the earth's surface Of this area, about 10,000,000 square miles are included in the *epicontinental* seas, the shallow waters which border the continents, and represent the overflow of the ocean on the continental shelves. The depths of these seas rarely exceed 600 feet

Plankton plants probably are much more numerous in the middle latitude and subpolar zones than in the tropics. The waters that bathe the shores of northern Europe and eastern North America represent a richer pasture of microscopic plant life than is to be found anywhere else in the world When it is realized that this area also contains two of the world's greatest fishing grounds, the significance of these minute plants in the economy of the sea should become apparent.

The rate of growth and reproduction of these plants, other things being equal, seems to be greatly accelerated along contact zones between tropical and arctic oceanic drifts, especially

[1] Of the drifting plankton plants, the Diatoms, the Peridinians, and the Coccuspheres are the most numerous and important In the temperate and colder waters, the Diatoms are most numerous, while the others prevail in the tropical and subtropical regions —Russell F S, and Yonge, C M *The Seas,* Frederick Warne & Co, 1928, p 114

on and near the continental shelves. Thus, the great fisheries of Japan are off the northern coast of Hokkaido, where offshoots from the warm Japan Current and the cold Oyashim intermingle, and on the Newfoundland banks we find the warm Gulf Stream and the cold Labrador Current in close juxtaposition.

Man procures nearly all of his marine foods from the comparatively shallow waters of the epicontinental seas. The nature of the food economy of the sea makes this situation inevitable, inasmuch as larger fish tend to live on smaller fish, and they on still smaller ones and on phyto-plankton and zoöplankton.

Plankton animals.—Wafted about on the waves of the sea, the plankton plants serve as food for countless numbers of minute *plankton animals,* the *zoö-plankton,* similarly floating about These animals are equipped with slender thread-like projections which enable them to enmesh the equally small and smaller plants, and thus live on them [2]

Collectively these minute forms of plants and animals constitute the marine plankton, the principal feedstuff of the food fishes The herring family, the greatest fish family in the world, lives directly on this form of life The herring, in turn, is not only the most important fish consumed by man, but is also the most important food for other fish. Parenthetically it may be stated that the sperm whale, one of the largest of known animals, subsists solely on planktonic life [3]

Fish and man.—The degree of popularity which fish have attained in the diet of man has depended upon the ease with which they can be procured and the relative scarcity and abundance of other foods. People inhabiting rugged littoral lands

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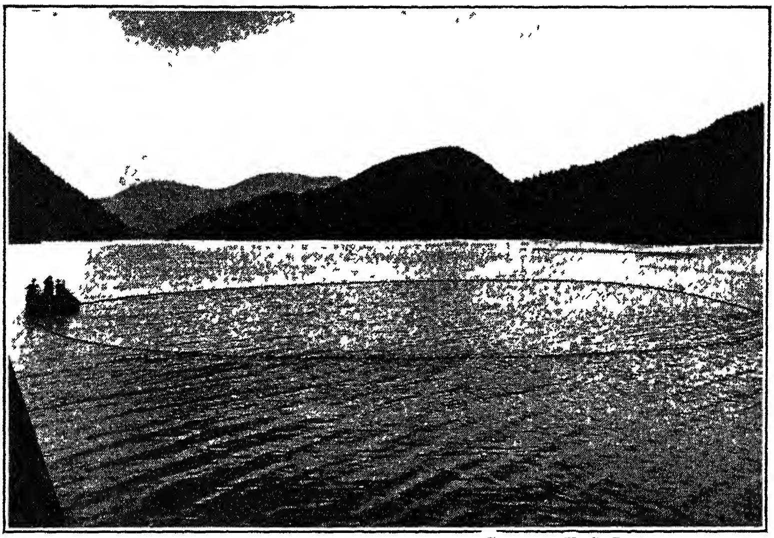
[2] As is usually true on the land and in the sea, a rich flora harbors an abundant fauna The conditions already described, which give rise to a rich phyto-plankton, likewise favor a rich zoo-plankton, and both together constitute the marine flora and fauna which is the fundamental basis of existence for the higher forms of marine animals

[3] Observation has established with reasonable certainty the belief that whales spend the breeding season in the more temperate and warmer waters In these waters the mammal becomes lean and gaunt because of the dearth of planktonic life Once he returns to the abundance of the polar seas, his parts readily become rounded

such as Brittany and Norway have long been proficient in testing the larder of the sea. The peoples inhabiting subpolar and polar areas where land life is not abundant must depend largely upon life of the waters for their sustenance. Again, where the ratio of land per capita of population is small, as in Japan, the seas assume an importance vital to the life of millions of people

Methods of fish capture.—Successful fishing depends not only upon the abundance of game, but also upon the ingenuity of man in using instruments of capture. The four main devices



Courtesy, U S Bureau of Fisheries

Fig. 280.—Catching fish with a purse seine off the Alaskan coast.

widely used are spears, traps, nets, and baited hooks. Spearing fish is a rather primitive method which is extensively practiced, however, in both tropical and arctic regions. Traps are used in shallow waters, but their total catch is relatively small. The bulk of the commercial fish is secured by means of baited hooks, or *liners,* and by various forms of nets, such as trawls, seines, and drift nets.

The particular method used depends on the habits and the habitat of the fish sought. Pelagic fish, living near the surface of the water, are caught largely by drift nets, attached to slowly

moving ships or floating buoys and kept vertical by means of weights attached to the bottom edge. The net is merely a stretch of strong cotton netting, approximately 60 yards long and 14 yards deep The mesh is of such a size that the fish is able to push its head through, but not its body When the gill-covers are caught, the fish can neither pull his head back nor his body through the net Herring, pilchard, and mackerel are among the fish caught by this method Seines are of many varieties and designs They usually consist of a large mesh which is used to surround a school of fish. Gradually the net is drawn closer, until a large number of fish are thus caught and may be removed either by hand or by lifting the net and its catch out of the water The method may be used partly on land and partly on water, or entirely in the water with the aid of small boats

Demersal fish live near the bottom of continental shelves, usually 200 feet or deeper In former days they were caught exclusively by liners These are really extended ropes from which small lengths of cord and baited hooks are attached at regular intervals. In places where the seabottom is rugged this system is still in vogue The modern trawl is the most popular device for demersal fishing It is a large net of flattened conical shape, sometimes as much as a hundred feet in length. As this huge bag is dragged slowly along the seabottom the fish are caught in its meshes. The trawl does well wherever the seabottom is smooth, but not where rugged or rough

The major fishing areas: *Japan.*—The three leading fishing areas of the world are the seas bordering central and northern Japan, the great fishing banks of the Atlantic off the coast of New England and Newfoundland, and the shallow waters off the coast of northwest Europe Each of these areas supports large fishing fleets and furnishes employment to thousands of people. From each the catch serves as an indispensable food supply and provides a commodity of high commercial value

Of the large world powers, Japan is most directly dependent upon the sea. The total land area of Japan proper is only 147,-500 square miles, or considerably less than that of the state of

California Because of ruggedness and unfavorable climate, but 16 per cent of the land is arable Since the total population is approximately 66,000,000 people, there is an average of about 1,400 for every square mile of land which is now deemed tillable

Japan, however, is fortunate in her resources of the sea Though narrow, the epicontinental seas that flank the islands are extensive, particularly in a north and south direction Furthermore, the warm Kuro Siwo on the eastern side and the cold Oyashim Current on the western side cause a mixing of waters that favors the sustenance of abundant marine life in the numerous inter-island straits and seas.

Because of the great north-south extent of these islands, the fisheries can be divided roughly into halves The sea to the north, particularly about Hokkaido, Sakhalin, and Kamchatka, constitutes one of the three great fishing grounds of the world. Principal catches here are of herring, salmon, cod, sardine, and various types of flat fish. About central and southern Japan the waters abound with bonito, sardine, horse mackerel, tunny, and various shellfish such as clams, crabs, oysters, and lobsters. The fisheries engage about 400,000 boats and more than 1,500,000 people

The people of Japan have few fish prejudices. Thus most fish markets offer such delectables as whale meat, shark meat and fins, octopi, cuttlefish, devilfish, and warty sea cucumbers, besides the best of fish that we consider palatable The Japanese eat fish, shellfish, or some other marine product at practically every meal.

That the sea is a generous provider to these islanders is illustrated by a practice very common in the larger seaside towns along the coast When the tide ebbs, many of the poor men, women, and children flock to the shores with sticks and vessels Every object with a spark of life, particularly shellfish and crabs, and also bits of seaweeds are gathered

In the light of these facts it is not surprising that Japan should have evolved a folklore and religion in which fish plays an important part. Nearly every household in the empire cher-

ishes a miniature god sitting on two bags of rice, the native staff of life, and another god with a fish under one arm and a fishing pole under the other. Priests make regular offerings to the gods of the fish world in full faith that by such offerings they may assure a bountiful catch to supply the multitudes with food.

The Atlantic fisheries of the United States and Canada — The development of colonial America was aided greatly by the wealth of fish found in the shoal waters of the North Atlantic. Colonial New Englanders were confronted at the outset with the difficulties of preparing the forest-clad and bowlder-strewn land for tillage Agriculture in most places involved much labor and brought small returns With an abundance of timber available, the settlers soon mastered the art of building fishing smacks by which the sea was made to supplement the food supply wrung so laboriously from the land

The banks off the coast of New England and Newfoundland constitute another of the three principal fishing grounds of the world They extend from Nantucket to the eastern coast of Newfoundland, a distance of about 1,100 miles, varying in width from 50 to 250 miles. The more important are the Grand Banks, southeast of Newfoundland, with an area of 37,000 square miles; the Sable Island Bank, southeast of Nova Scotia, with an area of 7,000 square miles, and the Georges Bank, immediately east of Cape Cod, with an area of 8,500 square miles As a whole they are the foremost cod-fishing grounds in the world Great numbers of American, Canadian, British, French, and Portuguese fishing vessels frequent them regularly. Although the cod is the most prolific in these waters, haddock, herring, flounder, and mackerel are also caught in large quantities

Menhaden are of major economic importance along the eastern coast of the United States Being migratory fish, they are caught from Florida to Maine, but the greatest number are secured in the waters bordering the states of North Carolina and Virginia. Since the meat is relatively unpalatable, because of its high oil content, it is not in much demand as food. The oil

is used extensively in the manufacture of soap and as a substitute for linseed oil in paints.

Fisheries of northwest Europe—The people inhabiting the coastal areas of northwest Europe have engaged in ocean fishing since early historic times Not, however, until about 1400 A D., after the Hollanders had devised improved methods of curing herring, did the fishing industry become of commercial importance The location of Holland on the North Sea and on the Rhine made it easy for the Dutch to procure fish, especially herring, and, after curing them, to sell them to the people of neighboring countries. This trade eventually extended so far southward that it included even the Mediterranean lands. So profitable was this traffic and the trade in other products which developed in connection with it that it gave rise to the well-known adage, "The city of Amsterdam was founded on the bones of herring" The renowned Dutch navy of the seventeenth century and the extensive trade of the Netherlands were merely children grown to maturity in an environment which stimulated their development The vast colonial possessions of the Netherlands today can be considered an indirect heritage from the North Sea fisheries.

England too adjoins the North Sea. While despotic kings thwarted for centuries the development of the fishing industry, when this restraint was removed the British fisheries soon exceeded those of the Netherlands. The continental shelf, of which the British Isles are an exposed portion, is unusually wide off the western European coast and includes practically all of the North Sea as far as the Shetland Islands These shallow waters extending from the Bay of Biscay to beyond the Lofoten Islands, off the Norwegian coast, together with those around Iceland, have given rise to the most far-flung fishing grounds of the world Collectively, they are in some respects the most important member of the world's trio of great fishing regions The principal fishing grounds are found in the North Sea, the Dogger Bank and the Great Fisher Bank being the most important. These waters are unusually rich in plankton. This is due to the

combined effects of several factors; namely, (1) shallowness of the North Sea, (2) the vertical circulation caused by the slow cooling of the waters of a branch of the Gulf Stream Drift which enters the North Sea between the Shetland and the Orkney Islands, and (3) the intensive mixing which results from strong tidal currents, the entrance of waters of low salinity from the Baltic, and the entrance of fresh waters from many rivers. Pelagic fish, such as herring and mackerel, wax fat on this plentiful plankton diet. The herring in turn are pursued by hungry cod, haddock, shark, and dog fish.

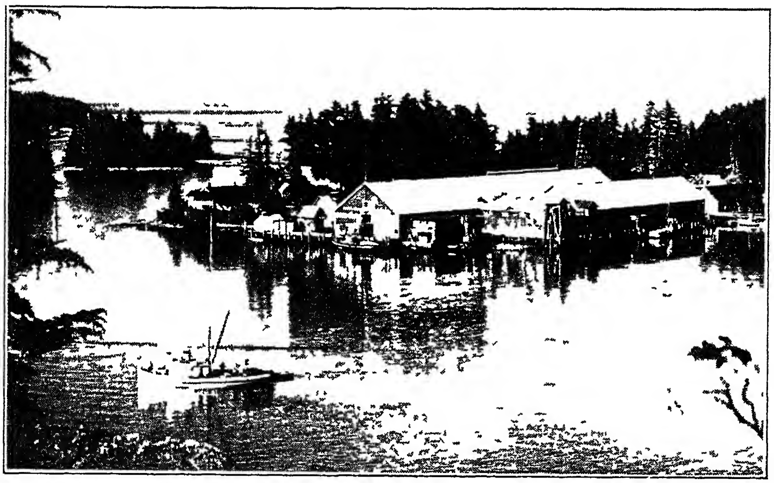
The annual catch in the waters west of Europe exceeds 4,000,000 pounds. Grimsby, England, is claimed to be the world's greatest fishing port. Other important North Sea fishing centers are Yarmouth, Hull, Aberdeen, and Bergen. Billingsgate, on the Thames in London, is the largest fish market in the world.

Northeast Pacific fisheries.—Although the three great centers already described have recognized leadership in the commercial fisheries of the world, their position is not by any means a monopolistic one. Among centers of lesser output the west coast of North America from California to Alaska has high rank, chiefly because of the tuna and salmon fisheries. The marked popularity of the salmon has furnished economic inducement for the growth of a great fishing and canning industry in a section of the world which is not densely populated.

The life habits of salmon render them easy prey to large-scale methods of fishing. As fingerlings they leave their first habitat of mountain lakes and streams and proceed downstream to the sea. After about three years they return for spawning in the fresh waters of their nativity. These returning hordes of salmon going up some of the major streams can readily be caught by machine methods. The catch is efficiently handled by the numerous canning factories which have been established along the coastal inlets and lower stream courses, this being particularly true along the northern Pacific Coast of North America. The canneries from Oregon to Alaska stand unrivaled in number and in capacity of output. The salmon packed in

the northeast Pacific fisheries has in recent years exceeded 400,000,000 pounds, reaching values of 60 to 70 million dollars annually.

In many places the activities of man have jeopardized the life of the salmon. Some of the coastal streams of our Pacific states have been diverted for irrigation purposes, and in some high dams have been constructed for the development of electrical power In either case the return of the salmon to their upstream habitats has been made more difficult. Lumbering ac-



Courtesy, U S Bureau of Fisheries

Fig 281.—One of the numerous salmon canneries on the coast of Alaska

tivities have frequently choked the streams, and in such instances, likewise, the return of the salmon has been rendered nearly, if not completely, impossible. Furthermore, the reckless catching of all fish possible, without regard to effect on spawning and reproduction, has led to serious depletion of supply Small salmon runs have awakened the respective governments to the dangers of continued depletion, and by international agreement conservation measures have been instituted to protect the salmon from ruthless and destructive exploitation

California is the foremost fish-canning state in the Union Salmon is of some importance in the north, while in the south-

ern part the canning of sardines and tuna fish is a major industry. The total value of the annual pack of the state approaches $20,000,000, of which sardines and tuna fish constitute by far the larger percentage. Because of the migratory character of these fish, the tuna is more plentiful in off-shore waters in early summer, whereas in winter sardines are the more abundant. Therefore, most firms find it advantageous to can both kinds, thus keeping their plants in nearly continuous operation and giving their labor all-year employment.

The deeper waters on the continental shelves in the northeast Pacific are the best halibut-fishing grounds in the world. Some of the Pacific halibut are even shipped to Europe in a frozen state Unfortunately, these fisheries have been so vigorously prosecuted that danger of serious depletion of supply appears to be imminent

Tropical fisheries—When a jet-black head splits a wave in the Polynesian waters and a Tahitian boy emerges with a squirming miniature devilfish, what is the figure that shall be entered on the world ledgers of values? Millions of tropical people sustain themselves by the wealth of marine life that teems in the waters about them. To estimate the amount or values of such catches is impossible.

The tropics contain no great fisheries This is due largely to the lack of great populations to produce heavy demands for marine foods While the warm seas do not support as much plankton as do those in the higher latitudes, other forms of plant and animal life are so abundant that fish do not lack food supply It is held by some that many tropical fish are soft and not so palatable as northern fish While this may be true of certain species, many others are fully equal in texture and flavor to the popular fish of northern waters. The several species of the snapper family, so common in the Gulf of Mexico, have few equals in quality and palatability.

The fish resources of lower latitudes have not been greatly exploited because of their distances from large market centers, difficulties incident to the preservation of fish in warm climates, and competition with a rather plentiful supply in northern

waters. A population faced with a problem of greater food economy, or one seeking greater varieties of palatable foods, would readily overcome these difficulties.

Man and the marine fish population.—A few generations ago it was held that the fish supply of the oceans was inexhaustible. The late Professor Huxley of England, for instance, concluded that the entire annual take of herring in Europe did not represent more fish than would be contained in any one of scores of schools. He further submitted that man was but one of a great host of animals living on these fishes, and that it mattered little which one of these hosts got the lion's share It should be remembered, however, that Professor Huxley was speaking in an age of relatively simple fishing gear. Since his time the steam trawler has been introduced for demersal fishing in ever increasing numbers Man even uses aeroplanes to assist him in locating schools of fish in order that he may catch them more abundantly As a result, signs of diminishing catches on many grounds are unmistakable.

The necessity of intelligent conservation of marine life should arouse the "splendid isolationist" out of his provincialism Actions taken by nations single-handed are necessarily inadequate; they can result only in small gains or in no gains at all The larger problems connected with the conservation of the great resources of the sea can only be solved through scientific research and by international cooperation.

The whaling industry.—Although whales have attracted attention ever since man began to sail the seas, for centuries the animal was considered chiefly as a curiosity and a fit subject for tall stories. Eventually whale oil, derived from the thick coat of blubber which protects this warm blooded animal from the coldness of the water, was found to be well adapted for use in lamps. The demand thus aroused initiated the hunt for the whale. Small shore boats were launched in charge of courageous men equipped with simple lances and spears. At first casualties were more often on the side of man than on that of the whale, but the prizes were such as to be highly profitable for those who survived.

During the past two centuries the Norwegians, British, and Americans have prosecuted the industry vigorously and persistently. In all the oceans of the world the whale has been pursued to the point of virtual extermination, except in the distant Antarctic waters, the ice-fringed "bottom of the world," which remain as a last haven of refuge for this largest of mammals.

In the first half of the nineteenth century the New Englanders held the distinction of being the world's foremost whalers The improved methods of building sailing vessels made it possible to launch ships for extended ocean voyages New Bedford and Nantucket were the home bases for great numbers of American vessels, the former being at one time the leading whaling port in the world The culmination of American whaling is clearly marked by the fifties, when at times more than 700 American whalers were plying the seas

In 1859 Colonel Drake drilled the epoch-making oil well in Pennsylvania Kerosene lamps soon followed, and whale oil lost its big market. Then in the sixties came the Civil War, upsetting all marine traffic; and from these two blows the American whaling industries never recovered.

In 1864 Svend Fayn, a Norwegian, invented the harpoon gun, and soon thereafter ocean steamships became common A steam-powered vessel equipped with a harpoon gun could not only cover a larger area, but could also overtake a whale promptly and readily kill him with little danger to human life While the old sailing vessels were in use, men merely stripped the blubber off the carcass while on the high seas. With steam vessels it was found practicable to tow the whale to a shore station where all parts of the animal could be utilized Whale meat and fertilizers were then added to the list of the profitable products of the industry

In the Northern Hemisphere the whaling industry has been declining for some time; this however has been offset in large measure by increased activity in the far southern seas. In 1904 the Norwegians established the first whaling station in the Antarctic Ocean, and soon thereafter numerous others were

established along the shores of Antarctic islands As operations increased, more whales were caught each year. Realizing that the game sought was in danger of extinction because of overzealous exploitation, the British government attempted to limit the catch by imposing restrictions on the operations of the shore stations To circumvent this restriction modern pelagic whalers were launched, the first one in 1925. These huge vessels are equipped with a slip in the stern which makes it possible to haul the whale bodily on deck Here he is readily dismembered and "cooked down."

Since great numbers of whales can be dispatched with promptness by this system, the problem is to find the animals A number of high-powered smaller boats accompany the larger vessels and engage in the actual pursuit and capturing of the whale

In recent years even seaplanes have been included in the equipment of Antarctic whale hunters By such means large areas of water can be scrutinized for signs of whales and information of discoveries broadcasted to the whale boats. These boats capture the animal in all possible haste and tow it to the floating factory Because of this efficiency, whalers have been able to make great catches in the last few years That such efficiency marks the beginning of the end, no one can deny. International cooperation in limiting the number of whales which may be caught yearly is imperative if disastrous depletion is to be avoided, and early action should be taken if this great resource of the sea is to be saved.

Fur seals.—Seals also are marine resources which have great economic significance, the Pribilof Islands off the coast of Alaska being the chief center of the fur seal industry There each year many thousands of seals gather from distant waters and remain for a few months while the young, known as pups, are born and grow large enough to swim into the ocean with their mothers. When the migration is on, the males reach the rookeries first. Later, by a few days or weeks, when the females arrive, the males engage in fierce combat for their possession The size of the harem assembled varies from five to fifty, de-

pending largely upon the pugilistic ability of the males The cows soon give birth to single pups, the numbers of each sex being about equal Since the harem system prevails, an excess of males soon accumulates. These bachelors, as they are called, are not permitted by the "harem master" to disport themselves in the immediate vicinity of the breeding grounds. Hence they assemble on what is termed "hauling grounds." It is from among these bachelors that the United States Government officials select animals for killing. This practice supports a flourishing industry, while at the same time an increasing seal population is provided for.

Courtesy, U S Bureau of Fisheries Photo by H J Christoffers

Fig. 282.—Part of the seal herd on one of the Pribilof Islands.

The story of the seal industry is one of exploitation, depletion, and then conservation. It is a story of wanton destruction which occurred chiefly during the nineteenth century. Before the slaughter began the seal population of the Arctic and Antarctic waters was estimated to be in excess of 10,000,000. Before the close of the century the Antarctic grounds ceased to be of commercial importance. The number of seals in the Arctic waters was reduced to a few hundred thousand, confined almost exclusively to the American-owned Pribilof Islands Although the Government at the close of the nineteenth century was putting forth strenuous efforts to conserve the seal herd, it was

confronted with a difficulty arising from the peculiar habit of the seal to spend the greater part of the year in the high seas Here pelagic sealing was prosecuted with vigor by Japanese, Russian, English, and American ships.

The United States Government, however, persisted in its treaty-making attempts, and in 1911 an agreement prohibiting pelagic sealing was entered into, an agreement which came none too soon. The surviving seal herd on the Pribilof Islands numbered about 124,000 As a result of the conservation measures instituted by our Government, this herd has again exceeded the million mark. It is the only fur seal herd of significance in the world today.

The Government officials compute with reasonable certainty the seal population from year to year The number of animals serves as a guide to the number of three-year-old males—the killing age—that is to be reserved for future breeding purposes Excess bachelors are driven from the hauling grounds to the killing grounds for slaughter Females are not killed, because their value for future production far exceeds the value of their skins The total "take" during the season ending August, 1935, numbered 57,296 skins, with a value, before being manufactured, of $1,800,000. Under the provisions of the treaty with Great Britain and Japan, 70 per cent of the skins are allotted to the United States and 15 per cent to each of the other two powers.

In earlier years London was the great sealskin market of the world, but in 1915 a number of the best seal dressers and dyers of London were brought to St. Louis, Missouri, which since then has held supremacy. The industry has become so expert in the handling of the furs that modern sealskin coats have become the popular symbols of aristocracy.

Other significant marine products.—Many other products, of varying significance, are or may be derived from the sea. Among the more outstanding ones the following deserve mention: salt, obtained from sea water; iodine and potash, derived from seaweeds; leather, from the hides of marine animals; agar-agar; pearls; corals; oysters; clams; shrimps; crabs; lob-

sters; and sponges The total value of all these major and minor products of the seas and oceans of the world cannot be computed with any high degree of accuracy Nevertheless, it is evident that the direct economic importance of the ocean as a provider of foods and raw materials is tremendous Furthermore, the indirect importance of the sea as a geographic factor in human affairs is so great that it staggers the imagination It is no wonder that those who live near it stand in awe and love at its majestic splendor, and that those remote from it have a deep desire to see it and to ride its waves.

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CHAPTER XXIX

Agrarian Regions and the Development of Industrial and Commercial Centers

THE significance of the uneven distribution of population has been discussed from several angles in the preceding chapters. While the unevenness is due partly to non-geographic factors, in most instances the basic causes are of an economic-geographic nature, and therefore the distribution of population tends to reflect the conditions of both the physical and the economic environment Some of the factors which may be responsible for sparseness or density of population were outlined in Chapter II Now, after a comprehensive study of the mineral and power resources and of the various climatic regions with their typical soils and agricultural products, we should be able to understand more fully the major causes which underlie the present distribution of the human race. We should realize that, although the future undoubtedly will bring important changes in the existing distribution of population, areas of sparseness and areas of density are permanent features of man's occupation of the globe.

Large portions of the earth will always be thinly populated, because they are climatically unfit for tillage agriculture, the only type of agricultural activity which allows at least a medium density of settlement In this category belong the polar regions and the major portions of the areas of subpolar climate The deserts and steppe lands of the world likewise will never be able to support more than a handful of people, except in local areas where irrigation water can be provided or where mineral wealth may be exploited.

Other parts of the world are sparsely populated because the climate, while favorable to the development of a luxuriant

vegetation, is unfavorable to man This is the case in the tropics, particularly in the rainy tropics, where diseases forestall a greater density of population With a better knowledge of how to fight various tropical diseases, with improved methods of sanitation, and when air conditioning becomes economically practicable, many of these regions can maintain a much greater number of people than they do now Expectation that they will do so should not be pitched too high, however, because of the leached soils which prevail in the more extensive areas of the rainy tropics

AGRARIAN REGIONS

The areas of low to medium density of population[1] are all predominantly agrarian in character. Here man, either directly as a farmer or rancher, or indirectly as a merchant or professional man, depends upon the products of the soil. The local industries are generally small, devoted to the manufacture of agricultural raw materials into marketable products of higher value This is well illustrated by the large number of dairies, small flour mills, and pork packing centers in some of the agricultural districts of the United States as well as by the beet sugar and potato starch factories in the agrarian districts of Europe. Although neither water power, coal, nor oil resources may be immediately available, some of the larger cities within such areas often develop into industrial centers of considerable importance, as for example Omaha, Memphis, Winnipeg, and Budapest Favorable location, excellent transportation facilities, important local markets, a large and easily accessible market area, and the availability of cheap labor from the neighboring agricultural districts often may explain such developments. In the minor trading centers also, which are scattered throughout all agrarian districts, small scale industries producing certain general necessities or specialties often flourish side by side with wholesale and retail establishments

Over considerable parts of the world where man lives pri-

[1] Up to about 100 inhabitants per square mile

marily by tilling the soil and by raising livestock the density of population, except in the immediate neighborhood of urban centers of considerable size, rarely rises above 100 inhabitants per square mile, and usually remains below 50 In semi-arid prairie or steppe lands—as for example in those of western North America or eastern interior Australia—small average yields must be counterbalanced by large farm acreages. In such areas the density of population often does not exceed 10 per square mile.

Agrarian regions of high population density.—In several

Photo by N A B

Fig. 283.—Sparsely populated agricultural region of the Central Plains of the United States. Large fields and scattered farm homes dominate the landscape

large and purely agrarian regions, however, densities of population occur which may run from 200 to more than 1,000 per square mile. Such is true particularly in some of the regions of old civilization, as in parts of British India, China, and Japan. These tremendous densities are possible only where climatic conditions are favorable to more than one harvest per year, where the soils are fertile, and where dependable crops—primarily irrigated rice—form the basis of the agricultural scheme But if no means of subsistence other than those of an agricultural nature are available, the upper limit of density—beyond which the standard of living falls to such a low level that people

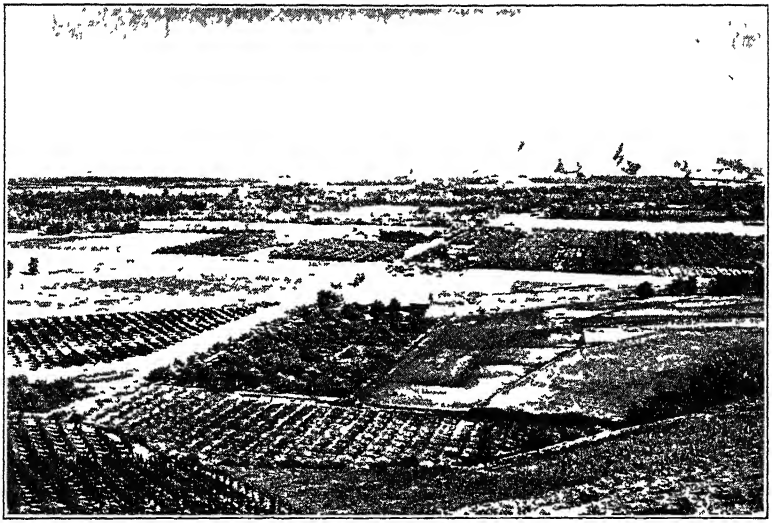
cannot adequately feed and clothe themselves—is soon reached The production processes of nature are slow even where the soil is fertile, where the climate allows several crops per year, and where man practices the most intensive "two and three story" [2] crop agriculture. Furthermore, where such exceedingly intensive methods prevail, it often becomes difficult to maintain the fertility of the land In parts of the Far and Middle East the population has increased beyond what the land can support even by the most intensive methods of farming In many densely populated parts of China an average of only 2 5 acres of agricultural land is available per farm family of six, and that often in scattered plots Thus, it is not surprising that very low standards of living prevail even when harvests are good, and that the average farmer does not have any appreciable economic resistence against such contingencies as occasional floods or droughts Even in Japan, where modern industrialization has made rapid strides and has absorbed at least a small part of the surplus country population, the agricultural basis of life is too narrow to afford the majority of the farmers more than the bare necessities of life

The cultural landscape in agrarian regions.—In areas of sparse as well as of dense agrarian settlement man has often profoundly altered the natural landscape. His field crops have partly or entirely supplanted the original vegetation of forest or grassland. He has built roads, railroads, and bridges; he has dug canals and brought rivers under control Dwellings, which always form an integral part of the cultural landscape, are generally the most conspicuous products of his technique

Where life is nomadic, shelters are not much in evidence because they must be movable and small of bulk—as for example, the tent of the Bedouin and the yurt of the Kirghiz; but where sedentary agriculture prevails, dwellings become fixed, and although renewed from time to time they tend to retain their character By the material employed they often show a direct

[2] Planting two or three crops on the same field at such intervals that while one crop is ready for harvest, another is nearing maturity and a third may just have started to grow

relationship to the natural environment, while their style may to a greater degree be a reflection of ethnic affinities. In the humid tropics wood and palm leaves are the principal building materials, whereas in desert areas adobe prevails—as in parts of the Sahara—and on steppe lands—as in southeastern Russia—sod is in favor. In the lowlands of western Europe, particularly in the Netherlands and northern Germany, where stone is scarce and lumber expensive, most houses are built of brick,



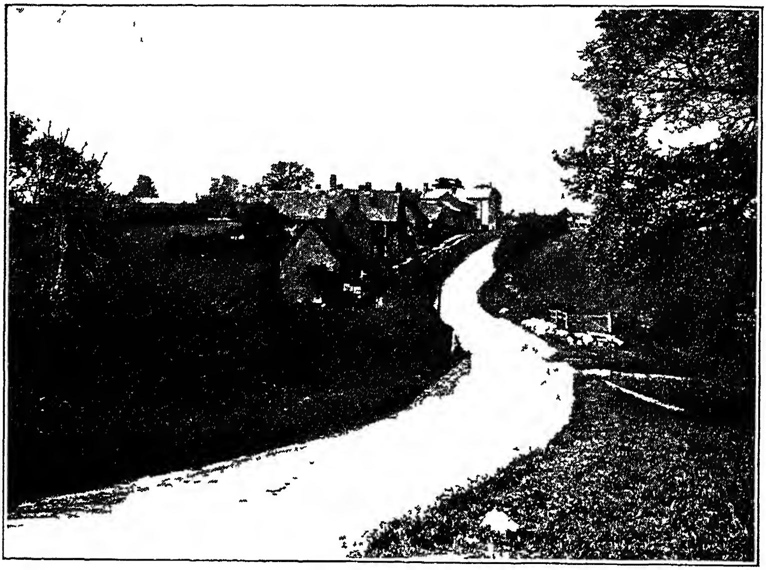
Courtesy, United States Bureau of Reclamation, Washington, D C

Fig. 284—Cultural landscape in the valley of the Naches River, near Yakima, Washington. Fruit growing is the principal industry. Mountains in the background show an untouched natural landscape, except for railroad constructed near the base.

while in the forested lands of northern Russia and Scandinavia log houses are dominant.

Mode of settlement in agrarian regions.—The dwellings of the agricultural population are generally not widely scattered over the countryside, but are grouped in rural villages. Wherever the farmer tills considerable acreage, it would be most logical for him to live on his land. But man is a social being and tends to congregate. Often the plots he tills are so small that there is no urgent necessity to live upon them, as in an oasis or

in a small forest clearing. In the Eastern Hemisphere, especially, settlement is very old; poor roads and insecure conditions have forced the farmers to live close together Although circumstances may have changed long since, the mode of settlement has remained unaltered; and at present nearly everywhere farmers live in groups. in hamlets or in small villages, each of which is surrounded by the agricultural and other lands belonging to the individual farmers or to the village community.



Courtesy, Associated British Railways, New York

Fig 285—A small village in one of the rural districts of England.

In recently colonized lands—particularly in the United States, Canada, and Australia—where landholdings are more extensive and where historical inertia does not play so large a role, the rural population generally lives scattered, each family on the land it owns or rents. In some of the older countries, likewise, one may occasionally find regions where the farmers do not live in villages. Nevertheless, in all such regions of scattered rural population small towns spring up, where the farmer may do his buying and selling, and where he may find all those

social and cultural amenities which are indispensable to civilized man

INDUSTRIAL-COMMERCIAL DISTRICTS

The regions of great density of population and high standards of living are almost without exception districts where man's principal economic activities are not of an agricultural nature, but where he exploits power resources. There he is engaged in the manufacture of goods or he makes a living by the buying, selling, and transporting of large volumes of commodities By modern machine methods man is able to produce industrial goods at a much more rapid rate and in much greater quantities than he can in agriculture, where he is entirely dependent upon the slow and relatively unreliable processes of nature. Thus, with a higher and more valuable output per individual, and with only limited requirements for land upon which to build the manufacturing plants, a much greater density of population is possible in industrial districts than in areas where man depends directly upon raw materials produced by the land.

Industry in the pre-machine and early machine ages.—In the pre-machine, or handicraft, age the primitive industries required large amounts of hand labor and they were scattered in the villages and small towns. The large cities of that time, though often important centers of industry, were predominantly trade emporia where the handling and distribution of considerable amounts of goods brought wealth to a few and provided a living for the remainder of the population.

Even in the early period of the modern industrial age the machines were simple, often performing only part of the manufacturing process, and requiring but very modest amounts of power A primitive water power development on a little stream in many cases sufficed to satisfy the demands for energy. Thus, for a while factories remained small and scattered. During the early decades of the nineteenth century, for example textile mills, with a few hundred spindles and employing only a few dozen people each, could be found all over southern New England in what would now be considered unfavorable, isolated

spots. (See figure 83, page 190) Similar conditions existed during the period of early industrialization in Great Britain

Industrial concentration near coal fields.—As industrial processes were improved, machines became larger, more complicated, and more extensively used, and factories grew rapidly in size. Consequently a large and cheap supply of power became a necessity for any important industrial development Such a supply was found in some of the coal fields of the world which were easily accessible and not too far from the principal centers of population. There coal could be used either as a fuel, or by means of the steam engine could be turned into dynamic energy. Thus, industries early began to congregate in or near the coal fields. Since coal is a bulky material of relatively low value, and, as the economists express it, is extremely "weight losing," it cannot be transported over long distances without incurring heavy freight charges and thus rendered too expensive for large-scale manufacturing industries

Principal industries associated with coal fields.—From the beginning of modern industrialization certain types of manufacturing industries have been closely associated with the mining of coal. Among these the iron and steel industry ranks first

With the increased use of machinery and the development of modern methods of rail transportation, the demand for iron and steel increased at a rapid rate The use of charcoal in blast furnaces had been abandoned relatively early, but the larger the furnaces and steel mills grew, the more they became dependent upon a cheap supply of coal as a source of both fuel and power Originally nearly two tons of coal were needed in the form of coke to recover the iron (as pig iron) from one ton of ore Consequently, where iron ore was not available in close proximity to the coal fields it was cheaper to ship the ore to the coal than to ship the coal to the ore.

At present, as a result of technical progress, the difference between the respective quantities of coal and ore needed, is much smaller On the other hand, since pig iron is only a semi-finished product, it must be made into cast iron or wrought iron, or converted into steel, through further processes of manufac-

transportation equipment, cranes and other hoisting machinery, wrought and cast iron pipe, nuts and bolts, forgings, wire, firearms, cutlery, and stoves The establishment of large-scale heavy industries in places where coal is expensive is as a rule uneconomical.

There are many other industries for which cheap fuel and power are essential, and which therefore tend to congregate in, or in the immediate neighborhood of, important coal fields; for example, the glass industry, the pottery industry, and those chemical industries which use coal tar—the tar residue which remains after the manufacture of coke—as a basic raw material Among others which tend to gravitate toward coal fields are the textile industries, especially the manufacture of cotton and woolen goods. The rapid growth of the cotton industry of the Lancashire district of England was possible only because of good coal available in the nearby fields on the west flank of the Pennines. Similarly, the woolen industry of Bradford and Leeds is located in the northern part of the east Pennine coal field Important textile centers are located in northern France near the principal French coal field, while the textile industry is also highly developed in the immediate neighborhood of the Ruhr.

Industrial districts as market areas.—In the industrial districts which thus developed, the concentration of manufacturing industries in the course of time became ever greater, as with advancing technique and more efficient organization plants continued to grow in size, and as with the multiplication of machine-made products various new types of industry were established in close proximity to power resources Hand in hand with this concentration of industry went a rapid increase of population density in the urban and semi-urban centers

As a result of these great agglomerations of people the industrial districts became important markets in themselves. A multitude of other industries, not directly dependent upon cheap fuel, but responsive to a great market demand and to relatively low costs of distribution over a small area, thus found a favorable economic environment. As illustrations of this de-

velopment may be mentioned the different types of food processing industries, the clothing industries, the manufacture of household and office equipment, electro-technical industries, printing, and various luxury industries.

Transportation development in industrial districts.—The growth of manufacturing in certain regions was accompanied by a perfection of the means of transportation, a condition *sine qua non* of modern industrial development Not only must raw

Fig 287.—Map of Ruhr district. An example of a semi-urban industrial region. Built-up areas shown in solid black. Dots are coal mines. Dense network of railroads.

materials be transported into and within the area, but also semi-manufactured products must be exchanged, and finished goods distributed Nowhere else in the world is the railroad web so dense and so intricately woven as in some of the large industrial districts. In the lower Rhine region of Germany, for example, there are over 25 miles of railroad per 100 square miles, while in highly industrialized and densely populated Belgium this figure even rises to over 55 miles. In the Ruhr district proper there are within a circumference of 25 miles over 3,000 miles

of railroad track. Where water transportation is available it is often used for short hauls as well as for relatively long ones. Not only are rivers deepened and regulated, but canals are built. Such for example is the case in northern France, Belgium, and the Netherlands The Ruhr profits by its favorable location near the Rhine River The principal British industrial districts all have easy access to the tidal waters, while those of the United States are either within easy reach of the Atlantic or of the Great Lakes waterway. In recent decades the network of roads has been greatly improved in most of the important industrial districts as a response to the rapid increase in the use of trucks as freight carriers.

Industry and commerce.—As a logical result of the abundant and varied production within manufacturing areas, the excellent facilities for cheap and rapid transportation, and the necessity of bringing in raw materials and huge food supplies for the dense population, an intense trading activity is the natural concomittant of any large scale industrial development. This factor adds to the employment possibilities and tends to promote the concentration of population.

Effect of industrialization upon the aspect of the cultural landscape.—Industrialization usually has far reaching effects upon the mode of distribution of the population and upon the aspect of the cultural landscape. It fosters the growth of industrial nuclei, leaving areas of sparse population in between In New England, for example, extreme density of population in the industrial cities and valleys occurs next to areas of sparseness on adjacent upland areas. Often agriculture, except specialized farming and gardening for the city markets, suffers from the loss of labor, owing to the greater remuneration offered by work in the nearby industrial centers

In some of the more extreme cases an entire region may become urbanized Mine hoists, culm piles, factory buildings small and large, innumerable smokestacks, rows upon rows of dreary tenement houses or workers' cottages, and vast railroad yards with miles of track all but obliterate the natural landscape Such conditions are found in the Ruhr Basin of Ger-

many and in the so-called Black Country between Birmingham and Wolverhampton, England.

The principal industrial districts of the world.—Most of the important industrial districts of the world have developed chiefly as a result of the congregation of manufacturing enterprises near rich coal fields Thus the majority of them are found in association with the principal coal basins in eastern United States and western Europe (see map, page 700)

United States industrial districts.—In the United States a

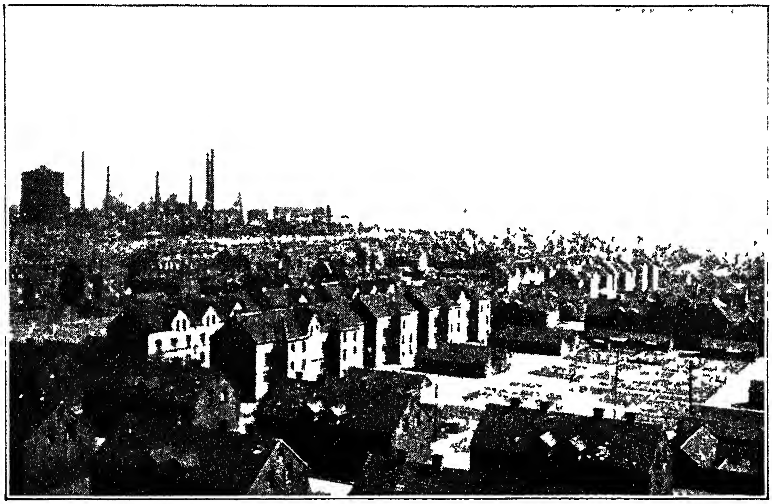


Fig. 288.—Industrial urban landscape in the Ruhr District near Hamborn, Germany.

highly industrialized and densely populated region stretches inland as a relatively narrow belt from the Atlantic coast between Boston and Baltimore to a line drawn from Cincinnati through Indianapolis and Chicago to Milwaukee, and including southern Ontario.

Within this section of North America several individual industrial districts can be recognized.

The Pittsburgh-Wheeling-Cleveland district.—The Pittsburgh-Wheeling-Cleveland district is closely associated with the northern Appalachian coal fields The presence of high quality coking coal has fostered the development of an ex-

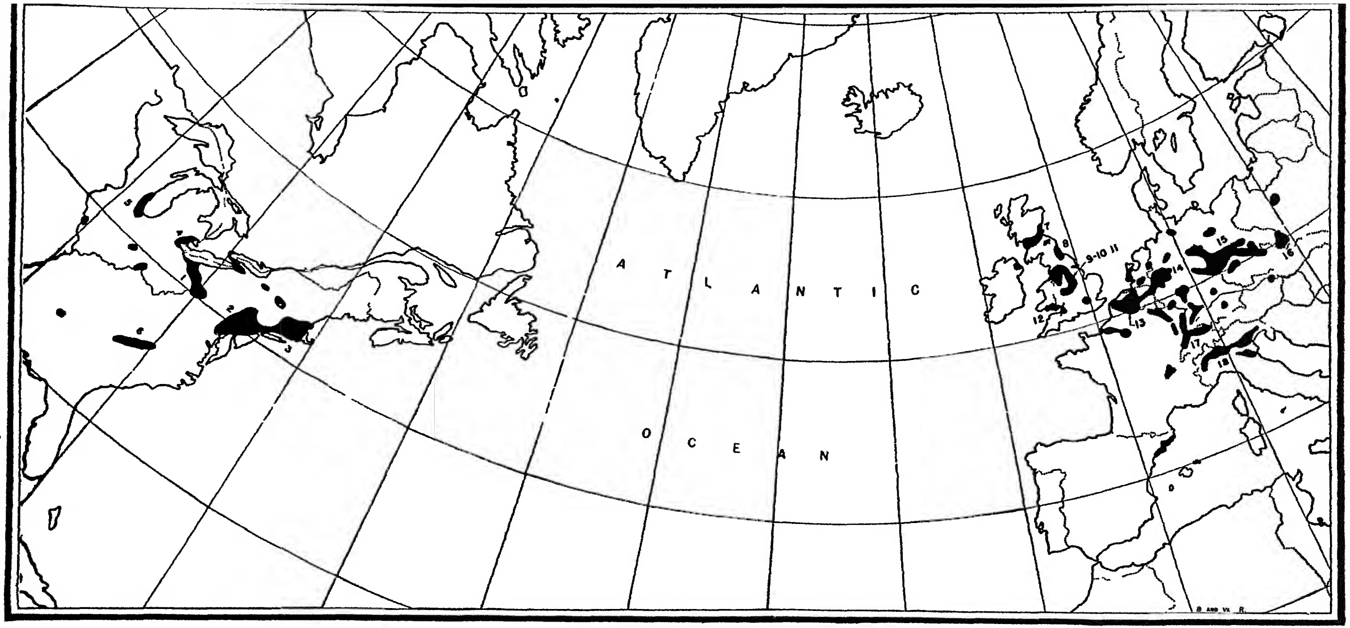


Fig. 289.—Principal industrial regions of eastern United States and western Europe. Lambert Conformal Conic Projection. (Base map courtesy of the U. S. Coast and Geodetic Survey, Washington, D. C.)

1. Pittsburgh-Wheeling-Cleveland district
2. New York-Philadelphia-Baltimore district
3. Southern New England district
4. Detroit district
5. Southern Lake Michigan district
6. Southern Piedmont district
7. Scottish Lowland district
8. Newcastle district
9. East Pennine district
10. Midlands district
11. Lancastria district
12. South Wales district
13. Northern France-Belgium district
14. Ruhr district
15. Central Germany-Bohemia district
16. Silesia district
17. Swiss Plateau district
18. Northern Italy district

tensive iron and steel industry which is able to import iron ores cheaply via the Great Lakes waterway. While the manufacture of iron and steel dominates, especially in the Pittsburgh and Youngstown centers, numerous other associated industries are found here; as for example, the manufacture of foundry products, bolts, nuts, screws, tools, tin cans, stoves, and motor vehicles. The Pittsburgh center has an important glass industry. Akron is the largest rubber manufacturing center of the world, and East Liverpool is noted for its manufacture of pottery.

The New York-Philadelphia-Baltimore district.—The New York-Philadelphia-Baltimore district, one of the most densely populated parts of the United States, includes, besides the cities mentioned, most of northern New Jersey and a considerable portion of eastern Pennsylvania The entire area is most favorably located for large-scale industrial development because it is within easy reach of the northern Appalachian bituminous and the Pennsylvania anthracite fields, and it lies close to tidewater, which facilitates the importation of raw materials and the disposal of the finished products not absorbed within the district itself. Industry is highly diversified, and both the total value of the products and the number of people employed greatly exceed those of the Pittsburgh-Cleveland district. In the Baltimore center the manufacture of clothing, tin ware, and the refining of petroleum and copper are among the principal industries. The Philadelphia center manufactures textiles and clothing, iron and steel, foundry products, electrical apparatus; it refines petroleum and sugar makes cigars and leather goods and a host of other products The iron and steel industry and the manufacture of foundry products, locomotives, silk, rayon, and knit goods are of considerable importance in other centers of eastern Pennsylvania. Among the principal industries of the New Jersey center may be mentioned the silk and rayon industries of Paterson, the manufacture of electrical apparatus and pottery, and the refining of petroleum and copper.

Diversification of industry is greatest in New York City, but

among the innumerable industries clothing and fur manufactures stand out as employing exceptionally large numbers of workers Among other important activities may be mentioned the manufacture of foundry products, electrical apparatus, chemicals, perfumes, knit goods and other textiles, and the printing and publishing industries

The southern New England district.—The early development of the textile industries of southern New England was due mainly to the availability of cheap water power. Coal was later imported from the nearby Appalachian region either by rail or by means of coastal navigation At present, as in most industrial districts in the United States, the energy used in the factories is mainly in the form of electrical current derived either from coal or water power. The textile and shoe industries still dominate the economic life of the region, but because of the competition of the southern Piedmont region the former is forced to specialize more and more in the manufacture of the finer goods The shoe industry also has suffered from the competition of factories which are located closer to the areas of production of the raw materials, such as those in St Louis and Milwaukee. In New England, however, industry has become quite highly diversified, especially in the Boston center Among the best known specialties are the brass and electroplating industry and the manufacture of firearms in Connecticut, the jewelry industry of Rhode Island, the manufacture of paper in the Connecticut valley of western Massachusetts and in southern New Hampshire, and the manufactures of carpets, wire, abrasives, and textile machinery in the Worcester center

The Detroit district—The Detroit district, which includes also the cities of Lansing, Flint, Pontiac, and Jackson, specializes in the manufacture of motor vehicles Directly or indirectly associated with this industry are important iron and steel, foundry, machine tool, wire, and paint industries Immediately to the west lies one of the important furniture manufacturing centers of the United States, that of Grand Rapids

The southern Lake Michigan district—The southern Lake Michigan district includes the Chicago area and parts of the

neighboring states of Wisconsin and Indiana, with the cities of Milwaukee, Gary, and South Bend. Because of its large market area and its easy access to both the iron ore of the upper Great Lakes district and the coking coal of the northern Appalachian field, this district is able to support a flourishing iron and steel industry Closely associated with this are an important foundry industry and the manufacture of railroad equipment, farm machinery, electrical machinery, power engines, wire, motor vehicles, and various other goods. Because of an extensive agricultural hinterland with which it has excellent communications, Chicago has become the principal meat packing center in the United States, the value of the animal products ranking a close second to that of the manufactures of metal. Among the other industries of this district should be mentioned the clothing, furniture, paint, and printing and publishing industries.

Other districts.—Among other important manufacturing areas within the industrialized belt should be mentioned the Mohawk Valley district from Buffalo and Niagara Falls to Troy, the Cincinnati-Dayton-Columbus district of southeastern Ohio, and the Indianapolis center Outside this belt the textile and tobacco manufacturing district of the southern Piedmont, and the St Louis and Birmingham centers are important Smaller industrial centers coincide with the urban areas of Minneapolis, St. Paul, Kansas City, Los Angeles, and San Francisco.

Europe.—In Europe industrial development is greatest in the British Isles, and in a belt on the continent which stretches from northern France to Czechoslovakia and southwestern Poland The major industrial districts of Great Britain, with the exception of that of London, all coincide with important coal fields.

Great Britain.—The Scottish Lowland district centers around Glasgow, where the prominence of the metal industries is indicated by the wide variety of manufactures ranging from railway locomotives to fine precision instruments Shipbuilding flourishes along the banks of the Clyde River, where some of

the largest ocean going vessels ever built have been launched

The Newcastle district also has a highly developed shipbuilding industry, and manufactures marine engines and railroad equipment. As in the Clyde district, the specialization in heavy products is largely a response to the accessibility of tide water In the northern part of the east Pennine district the manufacture of woolen goods holds sway, while farther south Sheffield is renowned for its metal products, especially cutlery.

The Lancashire district is the foremost cotton textile manufacturing region of the world. The industry centers in the numerous cities which surround Manchester, especially to the north. Besides textiles, chemicals and glass also are produced in large quantities. A short distance to the south lies the famous Potteries district where all sorts of pottery are made, varying from tile and crude earthenware to the highest qualities of chinaware. The principal city in this district is Stoke-upon-Trent.

In the Midlands district Birmingham has a highly diversified industry producing automobiles, rubber, rayon, electrical equipment, arms, and many other products, while Nottingham specializes in the manufacture of hosiery and laces

The London district, like that of New York in the United States, has a large number of highly diversified industries which profit from both excellent transportation facilities and the presence of an immense market.

Continental districts.—On the European continent the Ruhr and Lower Rhine districts of Germany stand out as highly industrialized areas Within a territory of less than 50 miles from east to west and 25 miles from north to south lie more than a dozen cities with populations varying from 100,000 to over 500,000, besides a host of smaller ones Here the iron and steel industry ranks first in importance. Among the numerous plants, those of Krupp and Thyssen are world famous Associated with this industry is the manufacture of all kinds of metal products, from the heaviest kind of machinery to knives

and needles. Among other industries of high importance are the textile and various chemical manufactures

Other important industrial districts closely associated with coal fields are those of northern France and Belgium and the Silesian district, which belongs jointly to Germany, Poland and Czechoslovakia. The central Germany and Bohemia districts, while developed originally on the basis of available coal and metal resources, are at present more definitely based on labor than on fuel However, cheap electrical power is available through the use of the large lignite deposits in Germany on either side of the Elbe River and in northern Bohemia Textile, machine, paper, porcelain, and glass industries are highly developed here.

Among the other important industrial districts of western Europe should be mentioned those of the Swiss Plateau and of northern Italy, both of which depend mainly upon hydro-electric power.

Other important industrial districts of the world.—In recent decades some important industrial districts have developed elsewhere, as for example the Donetz and Moscow districts of Russia, the Kobe-Osaka and Tokyo-Yokohama centers of Japan, the Shanghai center of China, and the Bombay center of British India. None of these, however, have reached the stage of high development typical of the older ones in Europe and North America.

Effects of distributable power upon industrial concentration.—The more recent and more easily distributable forms of power available to industry have thus far done relatively little to counteract the tendency of manufacturing industries to congregate in rather well defined areas Although found mostly outside the established industrial districts, petroleum and its products, fuel oil, gasoline, and natural gas, rather than attract industries, have tended to migrate to existing centers of manufacture by means of cheap pipe line transportation. A more important development has been the possibility of distributing electrical power, derived either from falling water or from coal,

over ever increasing distances The availability of cheap electricity at considerable distances from its place of origin will aid considerably in counteracting a degree of industrial concentration which might tend to become a danger to society, but it cannot be expected to cause a complete decentralization of manufacturing Areas where power is immediately available and where agglomerations of population constitute great markets will always be the most logical sites for certain types of industry.

COMMERCIAL CENTERS

The early development of overland trade depended not only upon the availability of a small surplus of goods of excellent keeping quality and high value, which could be exchanged for other desirable products, but also upon the existence of natural routes—either caravan trails, primitive roads, or navigable rivers At favorable points along such routes trade centers might develop especially at the junction of two or more land routes or rivers; at places which called for a change in the mode of transportation as at the head of river navigation or between transportation by sea-going vessels and river barges; where roads from plains areas enter mountains; or where roads from humid areas enter deserts. So, for example, Nuremberg, Germany, grew up as an important trade center where a route from the Danube to the Rhine crossed another from northern Germany to Italy Timbuctu, on the Niger River in Africa, once was an important trade center on the edge of the Sahara Desert where caravan routes from northern Africa converged St Louis developed immediately below the junction of the Mississippi and Missouri Rivers, and Denver at the break of transportation between the High Plains and the Rocky Mountains.

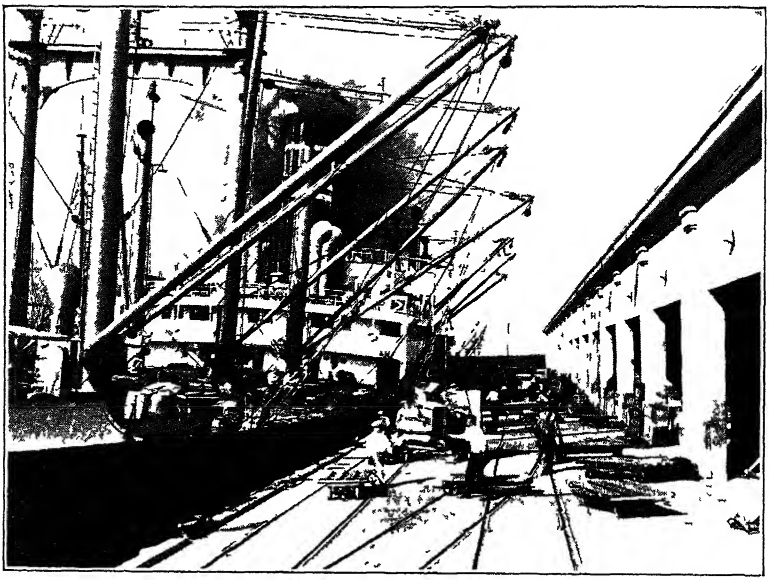
While the building of railroads and modern roads has tended to alter somewhat the necessary qualifications of a site suitable for the carrying on of trade, many interior trading centers, large ones as well as small ones, still derive their importance from a favorable geographic location.

Ocean trade.—Trade also early developed along coasts, especially along those which were rather highly indented and where ships could find many safe anchoring places Until the nineteenth century sea going vessels were small and the goods they transported were generally of little bulk and high value. As a result, the success of a port depended more upon the existence of a good, sheltered harbor, and upon a location safe from easy attack, than upon the accessibility of the hinterland Thus, in Greek and Roman times the ports of the Mediterranean region were small but numerous Even during the Middle Ages, and later, similar conditions prevailed in western Europe Many of the trading cities which belonged to the so-called Hansa League, for example, would be small and insignificant in our modern eyes

The importance of the hinterland in modern times.—Modern production requires both large-scale transportation and large-scale trade On land railroads and trucks have taken the place of primitive transportation by wagon train Ships engaged in ocean trade have grown tremendously in size Nevertheless, the advantage of a deep, sheltered natural harbor counts less today than the size and the accessibility of the hinterland of a port. Where nature is deficient in so far as the natural facilities of a port are concerned, modern engineering can do much to make up for these deficiencies; but it cannot provide the item most essential for modern large-scale trade· an extensive, flourishing, highly productive, and densely populated hinterland.

Thus Norfolk, Virginia, and Halifax, Nova Scotia, are located on splendid bays, but they have failed to develop into great trading centers for lack of a large hinterland On the other hand, New Orleans, located in the low delta lands of the Mississippi, and with an approach from the Gulf of Mexico which must be dredged continually, has become a flourishing port because it can serve as the outlet of an extensive hinterland, and because it lies in relative proximity to important centers of production in tropical America. Similarly, the ports of Hamburg and Rotterdam have not attained their ranking position

as world ports because of splendid natural harbors. Both have been forced to construct large artificial basins of sufficient size and depth to accommodate modern vessels of great draught, and both annually expend considerable sums upon the dredging of their approaches However, they each have a large, highly industrialized, and densely populated hinterland. Rotterdam is the port not only of the Ruhr district, but also of an area which extends far southward into Switzerland and France.



Courtesy, Chamber of Commerce of Los Angeles

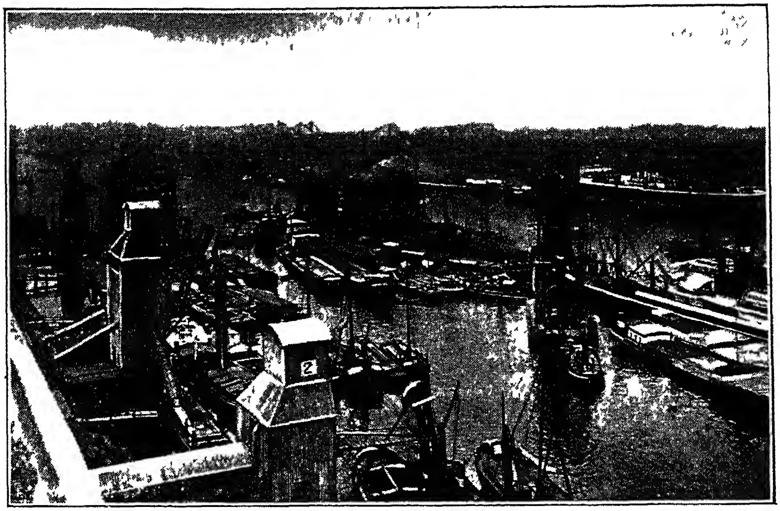
Fig. 290.—Ocean going steamer taking on cargo, Los Angeles, California.

Hamburg's hinterland embraces the industrial districts of central Germany and Czechoslovakia.

Principal ports of the world.—On account of differences in the statistical methods employed to measure the tonnage of incoming and outgoing shipping, it is difficult accurately to compare the relative importance of the principal ports of the world. There are still other factors which tend to complicate the problem In some ports the trade centers around bulk goods of relatively low value, as at Buenos Aires and Montreal, while in other ports the trade deals largely with finished manufactured

products of small volume and high value, as for example at Hamburg and New York. Furthermore, annual fluctuations of traffic are often large

Nevertheless, in so far as their role in international trade and the total tonnage of incoming and outgoing shipping are concerned, the following ports may be enumerated as belonging to the world's most important: New York, London, Liverpool, Hamburg, Rotterdam, Antwerp, Marseilles, Buenos Aires, Hong Kong, Shanghai, and Kobe.



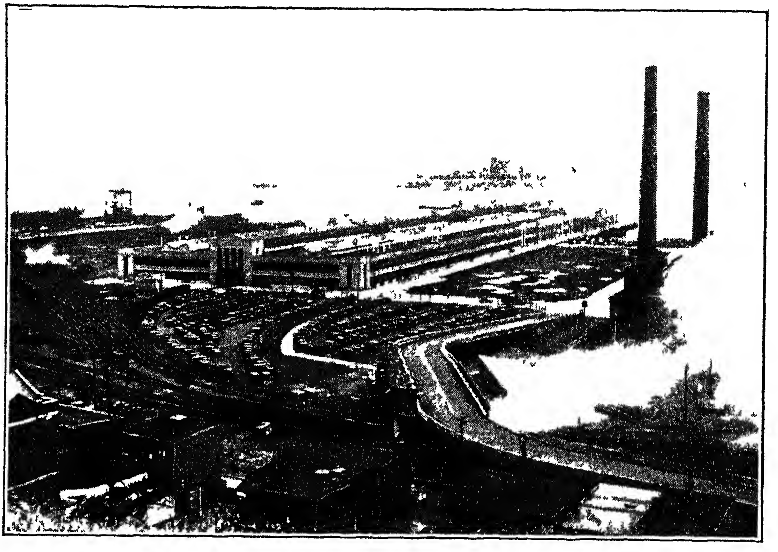
Courtesy, Netherlands Railways, New York

Fig. 291.—A busy port scene in Rotterdam, Netherlands.

Modern ports and industrial development.—Since most large ports are favorably located for the acquisition of raw materials and fuel, as well as for the sale of finished products both to the hinterland and overseas, many of the great seaports have also become important centers of industry Greater New York, for example, has developed into one of the principal industrial districts of the United States Similarly, industries of a highly diversified nature are found in and around such commercial centers as Rotterdam, Antwerp, and Hamburg.

The growth and role of cities.—People engaged in non-agricultural pursuits, particularly those engaged in trade, early felt

the need of living close together, partly because of the necessity of mutual protection, partly because of economic and geographic considerations Cities, when they were not created for political and military purposes, were primarily trade centers In the course of time many of them became centers of handicraft, and eventually of manufacturing industries. Cities still play this dual role· either industry or trade predominates, but the two are always found together In some of the newer coun-



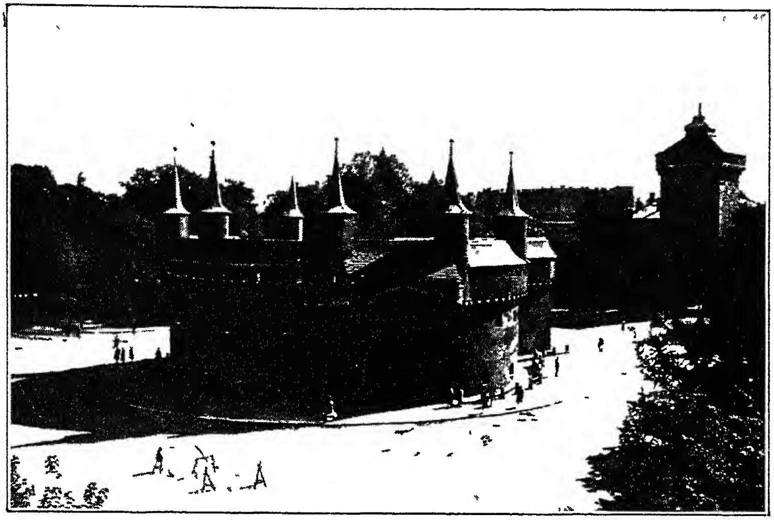
Courtesy, the Port of New York Authority

Fig. 292.—A large, industrial plant with ocean shipping facilities, on the Hudson River opposite Manhattan.

tries, as in the United States and in some of the coal regions of Europe, where cities are younger, many from the very beginning were primarily industrial settlements Only a few of the large cities of the world perform predominantly political and administrative functions Examples of this type are Washington, D C , The Hague, Netherlands, and until recently Peking, now Peiping, China. The original political role of a city has often been overshadowed by industrial and commercial development, as is the case with Berlin, an entirely artificial creation in a wide, infertile sandy plains area of northern Germany

The urban landscape.—Most cities of the world are old, and their urban aspect still is partly a reflection of factors and conditions which definitely belong to the past In the times of pre-machine warfare all cities were fortresses, surrounded by a wall with gates and towers and a moat Within those walls available space was limited, houses were crowded closely together, and streets were narrow and crooked.

With the rapid urban growth which accompanied industrial development, and with the invention of modern means of war-



Courtesy, Polish Government Photo by Photo-Plat, Warsaw, Poland

Fig. 293.—Gate and tower of the old city wall of Krakow, Poland. The city has now expanded beyond its old limits and the wall has been torn down.

fare, the walls became an obstacle to expansion Practically everywhere they were razed and the moats were either filled in or maintained as canals, while new and more spacious quarters were laid out around the old, compact center This is the urban pattern which still prevails in most of the older parts of the world As a result of increased population and modernized traffic it has been found necessary in many European cities to rebuild parts of the old core in order to widen the principal thoroughfares. This, for example, has been done on a large scale in Paris.

The cities in recently settled countries belong in a different category. Since land was cheap, they could be built much more spaciously. Streets could be wider, and where the topography did not impose serious obstacles the development could be mostly rectilinear. Practically all American cities belong in this class.

The small and medium sized American cities have many advantages over the older cities of like size in Europe. The residential districts usually are spacious and beautiful—with lawns, shrubbery, and trees surrounding the separate dwellings—in contrast with the European cities where—except in some recent developments, so-called "garden cities"—the houses are built together, fronting directly on the street and having at most a small garden in the rear. On the other hand, the commercial cores of many American cities built strictly for utilitarian purposes are generally of a monotonous and unattractive pattern.

The metropolis.—Modern industrial and commercial concentration has led to the development of cities of tremendous size, veritable metropoli, as New York, Chicago, London, and Berlin.

Such concentration of people as well as of trade and industry was possible only because of the perfection of modern means of transportation and the maintenance of all the services whereby a metropolitan agglomeration can be provided with foodstuffs and other necessities not produced locally but which are essential to its continued existence. However, from the point of view of human welfare many of these cities have become hypertrophied. The excessive aggregation of human beings within a small area has given rise to numerous serious problems of an economic as well as of a social nature Efficient transportation of great multitudes of people often constitutes a nearly unsolvable problem Furthermore, the provisioning of such immense, growing cities becomes increasingly difficult, and forms a most vulnerable spot on the large urban organism. Even greater and more pressing problems are those of cheap and good housing, of pure air, of disposal of sewage, of water supply,

and of facilities for open air recreation. In many cities the parks, which may be considered as constituting the lungs of the urban body, are pitifully small and totally inadequate, and land is so expensive that new parks can be created only at excessive costs.

From the human point of view a further growth of many of these cities seems highly undesirable, and it is to be hoped that in the future a better distribution of cheap power may aid toward a certain measure of decentralization.

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CHAPTER XXX

Manufactures and Commerce

HE who has a clear conception of the principal natural resources—their kinds, qualities, and uses—and the environmental conditions under which people in the various parts of the world make their living, has proceeded far toward an understanding of the fundamentals of economic geography While a complete view of the field can hardly be presented within the limits of an introductory volume, it seems advisable to emphasize somewhat more fully than heretofore the direct relationships which exist between the environmental factors and the geographic distribution and development of the principal manufacturing industries The major percentage of each of the large industries is found in the great industrial regions and districts discussed in the preceding chapter, generally in urban centers, or in close association with them The unparalleled growth of cities, so characteristic of the past half century, was a direct result of the development of machine industries. Conversely, industry profited from the abundant labor supply and the large but compact market areas offered by the urban agglomerations. Thus, manufacturing and commerce have been handmaidens in the great march of industrial progress during the past several decades

Economic and social significance of the manufacturing industries.—The economic significance of these industries is clearly shown by the added value attained through manufacture, and by comparisons of such values with those of other types of production. Because of its all-around development, the United States may serve as a splendid illustration It has large industries in the various fields of productivity Among the most prominent are manufacturing, agriculture, forest utiliza-

tion, mining and quarrying, and the fishing industries. These five groups are the chief sources of the national productive income. Their comparative importance is indicated by the amount and percentage of the whole supplied by each group during the last census year, 1929:

	Amount	Per Cent
Value added by manufactures	$31,885,284,000	62.7
Gross income from farm production .	11,916,600,000	23.4
Value of output of mines and quarries	5,887,000,000	11.2
Gross value of lumber production .	983,709,000	1.9
Gross value of fisheries .	123,054,000	24

The social significance of the manufacturing industries of the United States is indicated by the extent to which people are employed in them As classified by the census under the heading "Persons gainfully employed, 10 years of age and over," 14,111,000 individuals were engaged in the manufacturing and mechanical industries during 1929. This was nearly 30 per cent of the total number of people gainfully employed, giving these industries a strong lead among all the groups recognized in the Census Bureau classification

PERSONS OVER 10 YEARS OF AGE GAINFULLY EMPLOYED IN THE U S A

(Fifteenth Census of the United States, 1930)

Classification	Number	Per Cent
Agriculture	10,472,000	21.4
Forestry	177,189	36
Fishing and fisheries	73,280	15
Mining and quarrying	984,323	2.0
Manufacturing and mechanical industries .	14,110,652	29.9
Trade .	6,081,467	12.5
Domestic and personal service .	4,952,451	10.1
Clerical occupations	4,025,324	8.2
Transportation and communication .	3,843,147	7.9
Professional service	3,253,884	6.7
Public service . . .	856,205	1.8

Employment situations in the various industrial countries of the world are similar to those which prevail in the United States; such differences as exist are in degree rather than in kind Thus, the proportion of all persons gainfully employed

who are engaged in the manufacturing industries of England is 42 per cent, Germany 38 per cent, France 31 per cent, and Italy 24 per cent Even in Australia and Argentina between 25 and 30 per cent of persons gainfully employed are engaged in manufacturing enterprises It is readily apparent that in the industrial civilization which now prevails, the manufacturing and mechanical industries offer the most extensive fields of employment for labor. Factors which promote industrial prosperity likewise promote the welfare of the wage earners, and, through an increased demand for consumptive goods, promote markets for the products of the field as well as for those of the factory. The various productive and service occupations are inseparably interrelated; the welfare of each is dependent upon the wellbeing of all

Relative importance of the major groups of manufactures.—The development of machine agriculture and of the mechanized factory system has led to a general movement of population from the land to cities and towns This is true of all so-called progressive nations As industrialism has advanced, urbanization has increased in relative importance. While among peoples who use machines but slightly, as in Rumania or Russia, 70 to 80 per cent of the population may live on farms, in the highly industrialized countries less than 20 per cent may be engaged directly in farm pursuits Even in the United States, recognized as one of the greatest agricultural nations of the world, only 24 8 per cent of the population lived on farms in 1930, the continuing downward trend being indicated by the drop from 29 9 per cent in 1920. Inasmuch as the manufacturing industries constitute a fundamental factor in this movement of population, the need for their systematic study is evident. One of the first essentials in such a study is that of a definite classification of the different types of manufactures, in order that data may be so organized as to reveal the relative economic and social significance of the different groups and to show trends in their development.

Unfortunately there is no international system of classification of manufactures, and therefore it is difficult, and in many

instances impossible, to make comparisons between countries. The U. S Bureau of the Census has adopted a classification into 16 major groups which serves this country quite well. In order to obtain a fair idea of the relative importance of the groups, various criteria might be chosen, such as value of products, cost or quantity of raw materials used, capital invested, power used, men employed, or value added by manufacture Recognizing that no single criterion is perfect, we present the classification as determined by the factor of "value added by manufacture" in terms of percentage of total value added by

MAJOR GROUPS OF MANUFACTURING INDUSTRIES
OF THE U. S A

(Rank computed on basis of averages for 1919, 1929, and 1931)

Reports of Bureau of the Census

Group	Value Added by Manufacture		Average Number of Wage Earners	
	Per Cent of Total	Rank	Per Cent of Total	Rank
Textiles and their products	14.2	1	23.3	1
Machinery, not including transportation equipment	11.9	2	11.5	2
Food and kindred products	11.4	3	9.0	5
Iron and steel and their products, not including machinery	9.2	4	9.7	3
Transportation equipment, air, land, and water	7.6	5	7.7	6
Printing, publishing, and allied industries	7.3	6	4.1	9
Miscellaneous industries	6.9	7	5.1	8
Chemicals and allied products	6.3	8	3.5	11
Forest products	5.9	9	9.3	4
Non-ferrous metals and their products	3.4	10	3.4	13
Products of petroleum and coal	3.21	11	1.6	16
Stone, clay, and glass products	3.17	12	3.5	12
Leather and its manufactures	2.8	13	3.9	10
Paper and allied products	2.6	14	2.5	14
Railroad repair shops	2.5	15	5.1	7
Rubber products	1.9	16	1.7	15

All manufacturing industries

Value added by manufactures, average of, 1919, 1929, and 1931 $25,552,300,000

Number of wage earners, average of, 1919, 1929, and 1931 7,984,300

manufacture during the years 1919, 1929, and 1931. It is believed that this basis gives a reasonably fair indication of the economic rank of the various groups of manufactures during the past decade. In addition, the rank of each group is given in terms of the average number of wage earners employed during the same years. As used in the census reports, the term wage earners does not include salaried officials whose work is chiefly of directive or executive nature.

As shown in the foregoing table, the textile industries have undisputed lead both in percentage of value added by manufacture and in percentage of wage earners. However, if the iron and steel and the machinery manufacturing industries were combined, as might well be done since machinery is very largely made of iron and steel, they would rank first in value added by manufacture, although they would still rank below the textile industries in number of wage earners

Among the industries which rank low in the scale thus established, rubber and the mineral fuels products are noteworthy In both cases the reasons for their low rank are quite apparent Most of the coal is used with little processing after mining. The conversion to coke and by-products is perhaps the most important true manufacturing process applied to coal, and in that instance the further processing of the by-products into the numerous other products, such as dyes, drugs, and chemicals, must be credited to the chemical industries Petroleum refining is a true manufacturing process, but one which requires very little labor. It also yields a supply of relatively low priced by-products which are further converted into chemical products and so are credited to that group. Rubber likewise requires little labor in proportion to the value of the finished product These lines of manufacture rank high in industrial importance even though their percentages measured in terms of added value or of wage-earners are relatively low

Special consideration of some selected industries.—It is not considered to be the province of general economic geography to delve deeply into processes of manufacture; that is the proper field for more highly specialized studies in industrial

geography Economic geography must deal chiefly with the fundamental factors which give rise to industry, or which make its development possible, and with their economic consequences For most of the major industries this has been done in connection with the resources upon which they depend—as for instance coal, petroleum, stone, and the metallic minerals—or in connection with climatic and soil conditions as far as the various phases of agriculture are concerned Some of the major manufacturing industries, however, do not come clearly within any distinct realm either of natural resource or of natural environment, but are rather intimately related to both, and hence they merit separate discussion. The representative industries which come under this classification include, among others: textiles, chemicals, leather goods, machinery, and transportation equipment

TEXTILES AND TEXTILE PRODUCTS

Although these industries have numerous subdivisions, they fall naturally into three principal groups; namely (1) textiles, (2) wearing apparel, and (3) industries which make other articles from purchased fabrics. The first group includes all spinning and weaving mills, and through its manufactures provides the raw material for the other two; the second includes the factories which make wearing apparel; and the third consists of those industries which produce goods fashioned out of cloth or yarn for special purposes The raw materials used by the textile industries are chiefly cotton, wool, linen, silk, and rayon. In the quantity used, cotton far outranks the others named.

The textile industries.—The textile industries include the manufacture of the various kinds of cloth, such as cotton goods, woolens and worsted, linens, silk, rayon, knit goods, and various other specialized mixtures While the manufacture of rayon, chiefly from cotton or wood pulp, is a phase of the chemical industries, the making of goods of rayon is a textile industry. Among the textile industries the manufacture of cotton goods is distinctly in the lead from a world point of view as well as

from that of the American textile industries In the United States, according to the census, the value added by manufacture of cotton goods in 1929 was 28.1 per cent of the total for all the textile products For knit goods it was 20 per cent; for silk and rayon goods combined it was 15 per cent; and for woolen and worsted goods, 14.6 per cent Linen goods ranks among the minor subdivisions, accounting for but 2 per cent of the total for the entire textile-mill products group

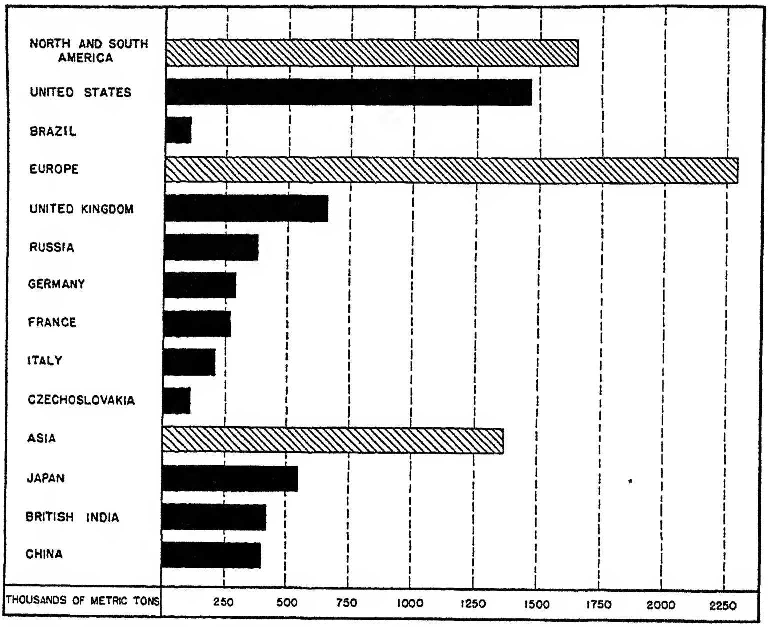
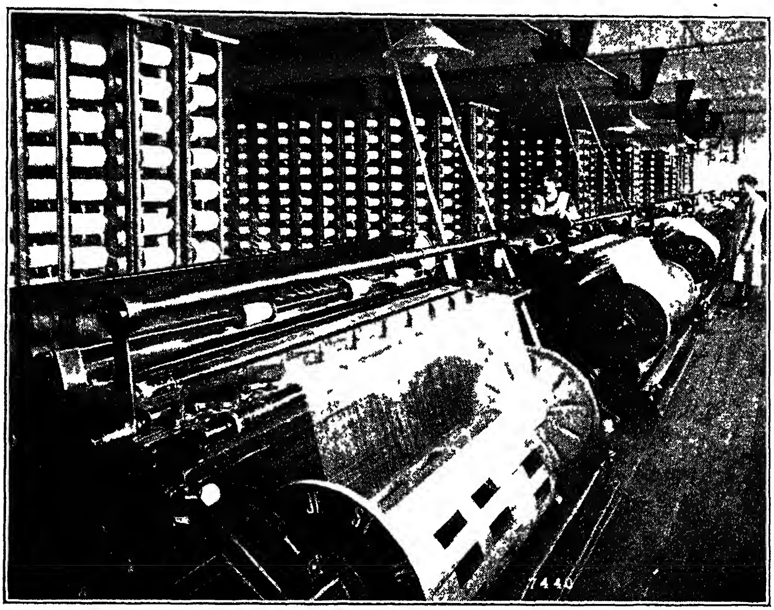


FIG. 294.—Consumption of cotton by cotton mills in principal countries. Average 1924–1930 (Source of data *Review of World Production, 1925-1931*, League of Nations, Geneva, 1932)

World distribution of the cotton manufacturing industries.—The demand for cotton textiles is world wide While locally and for specific purposes other materials may be in greater favor, nearly all the people of the earth make use of cotton fabrics in some form In warm and intermediate climates cotton textiles rank supreme; only in the regions of rigorous cold do they yield first place to wool and fur. Since large quantities of cotton are still used for the manufacture of homespuns, the

available statistics of mill consumption are not accurate measures of the production of cloth, yet they speak eloquently of the widespread use of cotton goods and the quantities of raw cotton involved Accepting the average for 1924 to 1930 inclusive as representative of the world's mill consumption of cotton, we find it to be 5,376,000 metric tons. Europe, as a continent, used 42.7 per cent of the total recorded, followed by North America and Asia with 28 1 per cent and 25.5 per cent



Courtesy, Platt Bros , Ltd , Oldham

Fig. 295.—Weaving cotton cloth. Interior view of mill in England

respectively, thus leaving but 3 7 per cent for the combined mill consumption of Africa, South America, and Australia.

It is noteworthy that Europe, although producing little cotton, accounts for greater mill consumption than any other continent. European-made cotton goods are used not only in Europe, but also in every other continent.

The cotton textile industry of Great Britain.—The cotton industry of Great Britain is concentrated in the Lancashire district, Manchester being the principal center Before artificial

means had been devised whereby a desirable degree of humidity could be maintained in the factories, the damp climate of Lancashire, caused by its location on the west side of the Pennine Mountains, was of great advantage for cotton manufacturing This advantage persists and is still of some economic value Furthermore, coal for power is available within the district, and the factories are within easy reach of the sea for the importation of raw material and the export of the finished products Because of the importance of Lancashire, Liverpool has long been the greatest cotton importing and trading center of the world. In recent years the district has suffered somewhat from the competition of new textile centers, especially those in the Far East and in British India

The cotton textile industry of the United States.—The outstanding characteristic of the cotton manufacturing industry of the United States has been the shift in geographical distribution of factories from New England to localities nearer the raw material In the first half of the nineteenth century, when machine methods of manufacture were becoming established in this country, the small streams flowing from the glacial lakes and swamps of New England provided easily developed power resources The streams were characterized by fairly uniform flow of clear water, and thus, through the building of small dams, numerous storage ponds were created and waterpowers suitable for the needs of the times were developed. Textile manufacturing became prominent because power was cheap and relatively efficient, the raw materials could readily be obtained by coastwise traffic, and large markets were available in the nearby city centers. Agriculture was finding it difficult to compete with the farm products from the new lands beyond the Alleghenies, and thus a supply of labor became available from adjacent country districts. When steam power came into prominence it served to supplement the water power, in some cases even to supplant it, but the acquired skill and the large capital investments served to keep New England's supremacy in textile manufactures undisputed until after 1880.

DISTRIBUTION OF ACTIVE SPINDLES BY PERCENTAGES OF THE TOTAL

Date	South (Per Cent)	New England (Per Cent)	Others (Per Cent)
1870	5.3	77.1	18.3
1880	4.6	81.0	13.7
1890	10.9	76.1	13.0
1900	22.4	67.6	10.0
1910	37.2	55.6	7.2
1920	42.9	51.5	5.6
1925	49.4	45.6	5.0
1930	59.5	36.3	4.2
1932	64.5	31.5	4.0

In comparison with the South, the relative position of the New England cotton industry has declined during the past fifty years, slowly at first and later at an accelerated pace. The number of active spindles grew steadily until after the World War,

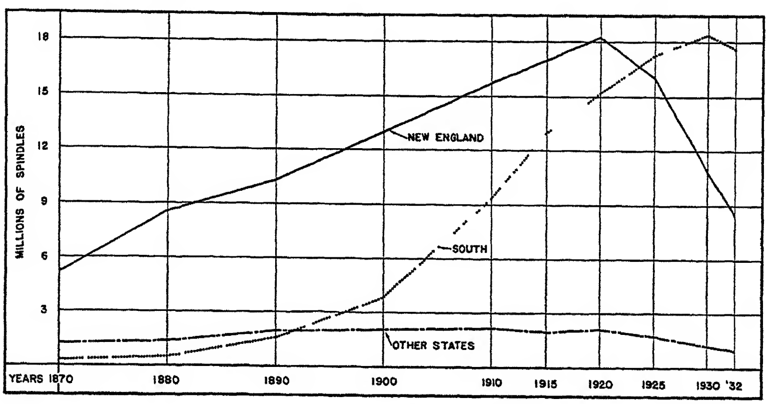


Fig. 296.—Active cotton spindles in New England and the South since 1870. (Source of data *Statistical Abstract of the United States*, Washington, D C)

though at a much slower rate than in the South; but since 1920 the number has actually declined, whereas in the South it has increased. In 1929, the southern mills processed nearly 75 per cent of the total amount of cotton consumed in the United States. The shift from New England was first toward the southeastern states, particularly the Carolinas and Georgia, but in later years there has also been marked development in the

western part of the Cotton Belt, where cheap power from mineral fuels has favored factory operation

As might be expected, the shift has not been the same in all grades. In general, those phases of textile manufactures requiring the least skill moved first, while those dependent upon quality of output have been slowest to shift Thus broadly speaking, the cotton textile industry of the present has three different centers namely, the newer ones of the South and Southwest, which are noted for their output of coarse goods and yarns; the Piedmont of the Southeast, noted for medium grade goods; and New England, which holds tenaciously to its fame as a producing center of high grade goods

Silk and rayon manufacture.—Silk, for centuries the aristocrat among fibers, has been supplemented by the newest arrival, rayon, to such a degree that the statistical data on the rayon and silk textile industries are inseparable It is well known, of course, that Japan and China are the greatest silk producers, and that their product is used not only in their own domestic industries, but is woven into genuine silk goods in various parts of the world, notably in Europe and North America In the United States the principal centers are in New Jersey, Pennsylvania, New York, and Connecticut, with Paterson in the first named state holding first place The 72 foot drop in the Passaic River furnishes power and the stream gives an abundance of clean water, both of which factors have proved to be of inestimable value in holding supremacy in the silk industry as well as in promoting its establishment at Paterson

The luster, fineness, and softness of rayon have, however, led to the manufacture of a vast array of mixed goods which have become popular for use in wearing apparel While rayon was first made during the latter part of the nineteenth century, its industrial growth was slow until after 1920, since which time the world output has expanded five- to six-fold. Among countries the United States holds first place in production by a wide margin, but Europe as a whole leads with about 60 per cent of the world's total Japan is the only nation outside of

Europe and North America which is prominent in rayon manufacturing; since 1927 she has made such progress that she has attained almost equal rank with France and the United Kingdom.

The rayon industry has made its greatest growth in countries where successful textile and chemical industries were already in operation There the essentials—raw materials, machinery, and technically skilled labor—were available and markets for the products were at hand. Low cost labor, where available,

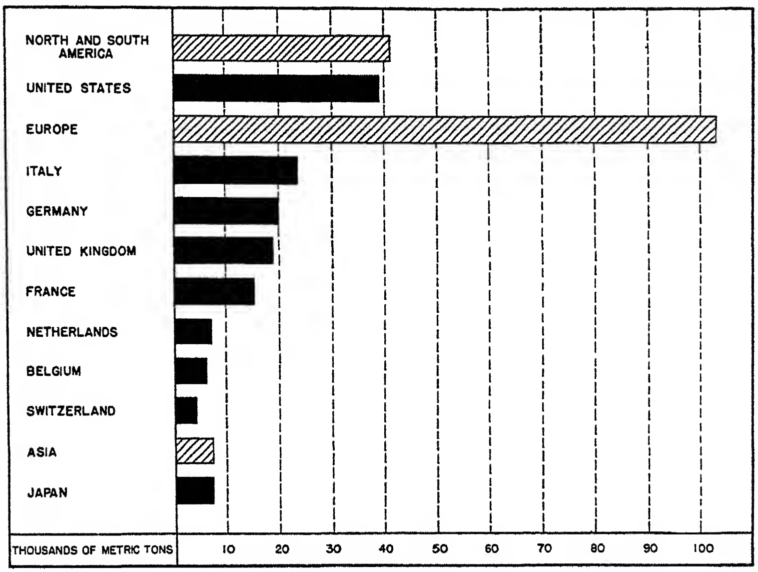


Fig. 297.—Production of artificial silk in principal countries Average 1925-1930. (Source *Review of World Production, 1925-1931*, League of Nations, Geneva, 1932)

as in Italy and Japan, has proved a factor which has gone far toward overcoming the handicap of less readily available raw materials.

In the United States the chief rayon textile centers are located in southern New England, in the New York City industrial area, and in eastern Pennsylvania. Wilkes-Barre and the Allentown-Bethlehem districts, as well as New York City, are among the world's greatest centers of silk and rayon manu-

facture. In 1929 the combined industries ranked sixteenth in number of wage earners, and the value of the products exceeded $700,000,000

Worsted and woolen goods.—The world's wool industry is unique in that the countries of the Southern Hemisphere furnish the larger part of the raw material, although they account for less than half of the world's sheep population. In the newer lands of the Southern Hemisphere sheep are raised chiefly for their wool, whereas in the northern countries they are distinctly dual-purpose animals, valuable for their mutton as well as for their wool.

The northern countries, with the United Kingdom holding first place, are the most prominent in the manufacture of wool goods On the basis of number of spindles, the United Kingdom is followed by the United States, Germany, France, Italy, Czechoslovakia, Belgium, and Japan, in the order named. During recent years France has made such strides forward that in quantity of wool consumed she is nearly on a par with England. Russia also is making such marked progress that within a few years she will probably assume a position among the leading countries in this industry As an exporter of wool products the United Kingdom holds the lead, a position which she will probably continue to hold for some time. Accessible raw materials from the British dominions, cheap power, skilled labor, established plants, and splendid connections with market centers all are factors conducive to success

In the United States the woolen and worsted goods industries taken together rank among the sixteen most important in number of wage earners employed The outstanding centers of manufacture are in New England and in Pennsylvania, with secondary centers in New York, Tennessee, North Carolina, Virginia, Michigan, and Oregon According to the last census more than 60 per cent of all the wage earners in the woolen and worsted industries were employed by the mills of New England

Knit goods.—The knit goods industry uses the various fibers —cotton, silk, rayon, wool—singly for some products and in complex mixtures for others. As a whole it is one of the most

important divisions of the textile industries, both as to kinds and value of products, and as to number of employes

According to the Fifteenth Census it ranked ninth among all the industries of the United States in number of wage earners employed. The largest manufacturing centers are the Philadelphia and New York City industrial areas. Others of major importance are Boston, Reading, Rome and Utica, Greenboro, Chattanooga, and Knoxville Southern centers have shown a definite upward trend in recent years. Their localization appears to be chiefly in response to economic rather than to geographic factors

Wearing apparel manufactures.—The production of ready-to-wear clothing for men, women, and children is one of the most characteristic results of the shift from handicraft to factory methods This development is pronounced in the United States, where the great majority of the men and a high percentage of the women buy ready-made clothing In the Old World the tailors and dress-makers are still to a considerable extent depended upon to make clothes to order, while in the humbler homes the housewives often do much of the garment making, particularly for the women and children. In recent decades, however, even in Europe the manufacture of ready-made clothing for men as well as for women and children has made great strides, the products appealing particularly to those in quite moderate economic circumstances

The manufacture of wearing apparel is one of the major industries of the United States In 1929 about 375,000 wage earners were employed in the making of clothing for men and women Inasmuch as the labor factor is exceptionally important, the clothing industry tends to be associated with great population centers. Some manufacture of wearing apparel is found in practically all important cities, and in that sense it is among the most widely distributed urban industries, but the main centers are located in the largest cities New York City holds first place in both men's and women's clothing, but has a much greater lead in the latter than in the former. In 1929, 51 per cent of all the wage earners in the women's clothing indus-

try were employed there, whereas the corresponding figure for men's clothing was only 19 per cent. Chicago and Philadelphia hold second and third places, respectively, in both branches of manufactures, but in men's clothing Rochester, New York, ranks fourth while Boston holds that rank in the manufacture of women's clothing. Secondary centers are found in nearly all of the large cities, but, because of various local factors, mostly of an economic nature, their respective importance does not correspond to the sizes of the cities. Among such factors are those of competitive occupations, vested interests, established commercial connections, and differences in degree of skill and interest in the clothing industries.

Taken as a whole, the textile and textile products industries are among the most important manufacturing activities of nearly all industrial countries. Since they deal with necessities of life comparable only with the preparation of foodstuffs, their relative importance continues through periods of adversity as well as of prosperity. They are therefore quite properly referred to as one of the main groups of basic industries.

THE MANUFACTURE OF RUBBER PRODUCTS

Rubber is one of the few major commodities for which the capital interests involved in production of the raw material are nationally distinct from those concerned with its manufacture. More than 95 per cent of the crude rubber is produced in the Malay States, Netherland India, and areas nearby, mostly under British or Dutch control. (See p. 418) The United States, however, has until recently provided the market for one-half to three-fourths of the world supply, the remainder going chiefly to European countries, the United Kingdom, France, and Germany being there the principal customers. Aside from the countries named, Canada has considerable importance, taking four to five per cent of the world total; in the Orient, Japan holds first place, generally using three to four per cent of the world's commercial supply of rubber.

A phase of the industry which is attaining increased importance is that of reclaimed rubber. Reclamation of used rubber,

particularly from tires, is now possible with little if any loss in quality, and hence serves as a bulwark against artificially stimulated prices As the price of crude rubber advances, the output of the reclaimed product increases In 1928 about one-third of all the rubber used was of the reclaimed type, whereas under the low price conditions of crude which prevailed in 1933 the proportion of reclaimed rubber dropped to about 20 per cent of the total.

The rubber industry is intimately related to that of the textiles in that most of the rubber manufactures have a fabric or cord base Rubberized cloth for rainproof apparel, and rubber boots and shoes were among the earliest products, and their manufacture is still an important phase of the industry The great demand for rubber has, however, been occasioned by the manufacture of pneumatic tires for bicycles and motor vehicles. The bicycle is an article of widespread use in Europe and even in the United States, although here it has been eclipsed by the mounting popularity of the automobile

Rubber in the United States.—In the United States the output of rubber products has practically doubled since 1914 in number of wage earners employed, and has nearly quadrupled in value added by manufacture In the industry as a whole the leading states are Ohio, Massachusetts, New Jersey, California, New York, Pennsylvania, and Wisconsin. The differentiation between tires and tubes on the one hand and rubber boots and shoes on the other is quite distinct Southeastern New England—particularly Massachusetts and Rhode Island—and New Jersey are the leading centers of manufacture of rubberized foot gear and wearing apparel. Nearness to the sea, with the consequent demands for sailors' apparel, and a climate which is characteristically quite moist, early led to the manufacture of various kinds of waterproof clothing In this field rubber has come to have an important place, and the factors named account in part for the prominence of these states. Ohio holds a commanding lead in the manufacture of tires and tubes, and also ranks well in the manufacture of other rubber goods. In 1929, 41 per cent of all the wage earners in the rubber manufac-

turing industries lived in that state Akron is often referred to as the rubber capital of the world In Pennsylvania rubber goods hold a slight lead over tires, whereas in California and Wisconsin the manufacture of tires and tubes is by far the leading phase.

American rubber goods are exported to practically every market on earth. Casings and tubes for motor car tires are the principal items; in 1933 they provided 56 per cent of the value of all rubber products exported The leading export markets for tires have recently been Brazil, the Netherlands, the Philippine Islands, Sweden, Cuba, and Belgium

THE CHEMICAL INDUSTRY

The chemical industry is one of the youngest and yet one of the most important branches of modern manufacturing In times of peace it supplies numerous materials to other manufacturing industries, and also to agriculture and to mining, while in times of war it is as essential as up-to-date military equipment The latter consideration has been a weighty argument in the fostering of chemical industries in countries where they did not exist or where they were only poorly developed before the World War

The chemical industry obtains some of its principal raw materials directly or indirectly from the mineral kingdom, such as sulphur and pyrite, ordinary salt, potash salts and phosphates, sodium nitrate, and coal tar. Other raw materials are taken from the vegetable and animal kingdoms, still others from water and even from the air

The importance of sulphuric acid.—Sulphur and pyrites serve largely as the basic raw materials for the manufacture of sulphuric acid, a substance which is indispensable in many processes of industrial chemistry The United States and Italy are the possessors of the largest stores of crude sulphur; Spain, Italy, Norway, and Japan are the principal producers of pyrite. The United States, highly industrialized and possessing a well developed chemical industry, ranks first in the production of sulphuric acid, but Italy, less developed industrially, ranks

only fourth or fifth among the European producers The markets for pyrites from Spain and Norway are chiefly in the countries of western Europe, especially Germany, the United Kingdom, and France.

In recent years the dominating position of sulphuric acid in the chemical industry has been lessened by various new technical developments. In the manufacture of soda from salt, sulphuric acid has ceased to be essential, in the manufacture of sulphate of ammonia, one of the nitrogen fertilizers, gypsum can be substituted for it; in the treatment of raw phosphates for the manufacture of superphosphates, electrolytic methods are gradually replacing the older acid-using technique. However, even in the face of these changes sulphuric acid remains an essential in the preparation of so many other products that its manufacture will undoubtedly continue to be an important economic activity.

Principal products and branches of the chemical industry.—The chemical industry manufactures such a host of different products that it is difficult to bring them under a few headings. Furthermore, while some chemicals may be considered as finished products, a large number of others are only semi-manufactures serving as raw materials for other branches of the industry.

The chemical industry proper produces not only sulphuric acid, but also a number of other important acids. such as hydrochloric acid, nitric acid, acetic acid, citric acid, and many others. The alkalies constitute another group of chemicals, among which the sodium carbonates deserve special mention The latter are sometimes found in nature, but more generally they are manufactured from common salt with the aid of limestone. The industry usually is associated with salt deposits, and the alkalies it produces are further utilized in the manufacture of soap Other important groups of chemicals are the bleaching compounds, used extensively in the textile industries, and the plastics (cellulose nitrate or pyroxylin, and others). Among the latter should be mentioned rayon, made from the cellulose contained in wood-pulp and cotton linters.

Among the principal specialized branches of the chemical and closely allied industries are the manufacture of fertilizers, explosives, dyestuffs, paints, drugs and medicines, and soap

Fertilizers —The manufacture of superphosphates and potash fertilizers depends primarily upon raw materials—raw phosphates and potash salts—furnished by the mineral industries. The potash industry is closely associated with the great potash deposits in Germany, France, and elsewhere, but the manufacture of superphosphates is related less to the deposits of raw phosphate, in northern Africa and Florida, than to the centers of consumption. The industry, therefore, is quite widely scattered In the approximate order of their importance the principal manufacturers of superphosphates are the United States, France, Italy, Spain, Japan, Australia, Germany, and the Netherlands The total production of Europe is more than twice that of North America.

Nitrogen fertilizers are produced in different parts of the world and in various ways The soda nitrate mined in Chile, although it has lost its monopoly, still occupies an important position on the world market, providing in normal years 20 to 25 per cent of the world's supply At present, however, the principal nitrogen fertilizers are provided by the chemical industry, in the form either of calcium nitrate or calcium cyanide, both of which are synthetic products. The industry is largely in the hands of the few leading chemical concerns of the world, and its location is generally determined by the availability of cheap hydroelectric power Norway is the leading producer of lime nitrate, while Germany manufactures most of the calcium cyanamide, followed, although not closely, by Canada, Japan, Poland, Italy, and France.

Another important source of nitrogen is ammonium sulphate, which is primarily a chemical by-product of the coke industry, although smaller quantities are produced by some of the other chemical industries. Europe accounts for nearly four-fifths of the world production of this fertilizer, Germany occupying first place Other large producers are Great Britain, the United States, France, and Japan

in countries with a highly developed chemical industry. As a result, their manufacture shows a distribution somewhat similar to that of the chemical industry as a whole.

Soap.—Soap is made from animal or vegetable fats with the aid of alkalies, such as soda or potash. The principal fats used are tallow, coconut oil, cottonseed oil, palm oil, peanut oil, and olive oil.

In the United States the industry is found in nearly all states, but the more important centers are in the East and in Ohio, Illinois, and Missouri. France is noted for its production of fine toilet soaps

LEATHER AND LEATHER GOODS

Leather serves many purposes While the bulk of it is made into footwear, considerable quantities are used in machinery belting for the transmission of power in factories and for the manufacture of gloves, luggage, and many luxury articles.

The manufacture of leather.—The raw material used by the leather tanning industry consists of the hides of cows and horses, either salted or dried, and the skins of numerous smaller animals, such as sheep, goats, pigs, calves, alligators, snakes, and others With the aid of tannin extracted from different barks, woods, or fruits—such as oak and hemlock bark, quebracho wood from South America, or the cup of a particular kind of acorn from Asia Minor—these hides and skins are made into leather Chemical tanning materials, especially chromium compounds, are used extensively for the manufacture of light types of leather, such as those in demand for gloves or uppers for shoes It is estimated that nearly one-half of all the leather manufactured in the United States is chrome-tanned.

While originally a rather close association existed between the tanning industry and the forests which furnished the tanning bark, the manufacture of extracts and the increased use of chemicals have not only eliminated many small tanneries, but have also induced a migration of the industry to important manufacturing and market regions and to coastal districts which have easy access to imported hides and skins.

The principal types of hides and skins used are those of domestic animals, and since these animals are found all over the world, the tanning industry is quite widely distributed Among the producers of leather, however, four countries hold outstanding rank in world trade—namely, the United States, Germany, the United Kingdom, and France None of them have domestic production of hides and skins large enough to cover the requirements of their tanning industries. All four import large quantities of raw material from some of the newer, less highly industrialized countries—particularly Argentina, Uruguay, Australia, New Zealand, and the Union of South Africa—which have a surplus of animal products, or from tropical countries, as for example, British India, where the population, mostly bare-footed, does not offer a great domestic market.

Leather tanning in the United States.—As mentioned, the American tanning industry depends both upon a large domestic production of hides and skins and upon large imports The domestic supply consists of hides and skins furnished by the meat packing centers in the Middle West, and of those which are produced on a small scale on farms and in rural towns The so-called "packer hides" are generally preferred by the tanning industry, because of greater uniformity of workmanship, and therefore they constitute the principal domestic supply. Hides and skins are imported from many countries, even from such as have highly developed tanning industries, as the United Kingdom, France, and Germany. However, the bulk of the imports are received from Argentina, Uruguay, Brazil, Canada, New Zealand, and Australia

The geographic distribution of the tanning industry within the country still reflects to some extent the influence of two principal tanning materials. oak bark and hemlock bark The oak tree is most common in the Appalachian Mountains, from Pennsylvania southwestward, while the hemlock occurs farther north in a belt which reaches from New England through New York and Pennsylvania to Wisconsin. Thus, North Carolina, Virginia, West Virginia, and Michigan still produce considerable amounts of leather, although none of them have large

leather goods industries. Pennsylvania ranks first in leather production, partly on account of the early availability of oak bark and partly because the center of origin of chrome tanning, Philadelphia, is within that state At present much of the leather is manufactured in or near the states which have an important boot and shoe industry, as Massachusetts, New York, New Jersey, Illinois, and Wisconsin

Leather goods industry.—The countries which produce the largest quantities of leather are also the principal manufacturers of leather goods Among the various products of this industry shoes and boots rank first

In the United States the oldest and foremost center of shoe manufacturing is in eastern Massachusetts and the adjoining portions of New Hampshire and Maine. Cities noted for this industry are Haverhill, Brockton, Lynn, and Boston in Massachusetts, Manchester in New Hampshire, and Auburn in Maine. During recent decades the New England shoe industry has lost some ground to rival centers developed elsewhere

The New York industrial region ranks second in the manufacture of leather footwear and is especially noted for women's shoes Another center, although of secondary importance, is located in southeastern Pennsylvania, in Philadelphia and some of the neighboring towns, such as Lancaster, Lebanon, and Reading In Ohio the industry is found in and near Cincinnati and Columbus

The shoe industry has shown a marked development in the states farther west. Missouri now ranks third in value of output of boots and shoes, the St. Louis industrial area being the chief center Illinois and Wisconsin also are important shoe manufacturing states, with large factories at Chicago and Milwaukee Exports of American shoes are shipped mainly to Cuba, Canada, and Mexico

The principal glove manufacturing district in the United States is located in the Mohawk Valley of upstate New York, where the towns of Gloversville and Johnstown manufacture over half of all the gloves made in this country

Among the other countries which have an important shoe in-

dustry, England is known for its excellent qualities of men's footwear. The French shoe industry is outstanding because of its quality and luxury production, primarily of women's shoes. French and English gloves are in demand the world over. In recent years Czechoslovakia has become an important exporter of footwear, mainly of women's shoes

THE MACHINERY MANUFACTURING INDUSTRIES

The conversion of ores to metals, the refining of metals, and the manufacturing of alloys are properly within the province of the metallic industries—that is, the iron and steel, copper, aluminum, and other industries The shaping of these metals into specific parts and their assembling into workable units is the province of the machine industries The metallic industries are generally quite directly associated with the supplies of raw materials and of power, either or both On the other hand, the machine industries have developed more definitely in response to available skilled labor and to markets in need of their products.

The extent to which countries produce machinery is a fairly accurate criterion of their degree of industrialization. The countries of Europe and North America are the only ones with highly developed manufactures of machinery In Asia, Japan has attained moderate prominence, and India and Russia, having made creditable beginnings in this field of industry, may be expected to show consistent growth in the years ahead.

For the machine industries as a whole, the leadership of the United States is undisputed; in point of value the output in this country probably exceeds that of all the rest of the world combined. This supremacy must be attributed to the wealth of raw materials of manufacture, plentiful fuel and power resources, abundance of land and other resources open to development, lack of cheap labor, inventive genius of the people, and a stable government which has made capital feel secure on an investment basis. No single factor or group of related factors can suffice to account for the industrial achievement of today;

it is the result of many factors, some environmental, some economic, and some social.

As classified by the census of 1929, the manufacture of machinery, not including transportation equipment, ranked first in value added by manufacture and second only to the textiles in number of wage earners In that year the industries included in this group employed 13 per cent of the wage earners employed in all manufacturing industries, and the products accounted for 13.6 per cent of the value added by manufacture That they are quite susceptible to economic conditions is shown by the shift which occurred in the following two-year period. Compared with 1929, in 1931 they had dropped about 50 per cent in value added by manufacture and 37 per cent in number of wage earners, these contrast with 37 6 per cent decline in value added by manufacture and 22 per cent in number of wage earners for all groups of manufactures taken as a whole

Three branches of the machinery industry which are of unique importance because of their relationships to the industrial system in general are (1) the machine tool; (2) the textile machinery, and (3) the agricultural machinery industries.

Machine tool industry.—The machine tool industry embraces the establishments which are engaged primarily in the manufacture of power-driven machines which are to be used as tools for work on metals This is a fundamental industry in the sense that its products—such as power drills, lathes, saws, shears, and forges—are necessary in the manufacture of other machines which are to be used for specific purposes—as for example sewing machines, typewriters, pumps, and so forth

On the basis of the number of wage earners employed, the leading centers are located in Ohio, Connecticut, Illinois, and Massachusetts It is noteworthy that of the four leading states, two are in the interior and two on the Atlantic seaboard There is no clear cut differentiation in the products made, and it seems quite evident that the chief factor involved in their location is accessibility to the factory centers where prompt service in providing and maintaining tooling machines is needed

Textile machinery.—The textile machinery industry includes the manufacture of equipment used in the various kinds of textile mills, from jute to silk, and through all the processes, from working raw stock to finishing the finest fabrics This industry flourishes to a greater or less degree in connection with the textile manufacturing districts in the various countries. Those which have large textile industries invariably have important textile machinery manufactures This is true of the United States, the United Kingdom, France, Germany, and Italy. Countries of lesser importance in textile manufactures buy their textile machinery abroad to a large degree

In the United States, Massachusetts holds first rank by a wide margin; in 1929 she employed about 40 per cent of the wage earners engaged in this industry. The states following her in rank were Pennsylvania, Rhode Island, and New Hampshire The early importance of the textile industries in northeastern United States served as the impetus toward establishing textile machine factories there also, and the skill in manufacturing, together with an established reputation of the products, has served to hold the industry in that section notwithstanding the southward movement of the cotton textile industry It is noteworthy, however, that textile machinery factories are beginning to develop in the southeast, particularly in the Carolinas, South Carolina being sixth in number of wage earners in 1929

Agricultural implements.—Every nation uses agricultural implements of some kind in connection with its farming activities, their character depending upon the nature of farm operations carried on Where labor is cheap, as in India or China, the machinery is simple, most of it hardly more than tools—such as spades, hoes, rakes, and flails Where fields are small and labor only moderately plentiful, as in Sweden or France, more complicated machinery, but of relatively small size, is needed. Only in countries where fields are large and labor scarce and high priced, as in Canada, United States, Argentina, and Australia, are there demands for large and highly efficient agricultural implements. Such countries constitute the chief markets for this line of goods

In the manufacture of agricultural machinery adapted to large fields and few men it is inevitable that the country which has a large home market should have the initial advantage If that country is also the scene of rapid progress in other industrial lines the advantage is doubly effective The results of experimentation under the typical farming conditions which must be met are close at hand and are therefore conducive to progress and further improvement The United States has had the advantages of all the factors involved—namely, the availability of raw materials, power, labor skilled in mechanical pursuits, capital, and markets—to a degree not reached in any other country As a result, it has become by far the foremost nation in the manufacture of agricultural implements

Principal centers of manufacture.—The states leading in the manufacture of farm implements are Illinois, Indiana, Wisconsin, New York, and Ohio It is to be noted that four of the five are in the great farming belt where relatively large-scale agriculture prevails. Illinois is far in the lead in every respect, in 1929, 54 6 per cent of all the wage earners in this industry were employed in the factories of that state Indiana ranked second with 8 8 per cent

The centers of manufacture within the United States conform to the general principle previously stated—that is, they are located near regions where their products are most needed and where the essential raw materials, power, and labor are readily available The central location of Illinois is also distinctly advantageous from the standpoint of distribution.

Foreign trade in agricultural machinery.—During the decade 1920-29 agricultural machinery was one of the major items of the American export trade; in 1929 this item exceeded $140,000,000 or about 50 per cent of the total value of all the agricultural machinery manufactured that year. The principal customers were Canada, Argentina, and Russia. The depression years following wrought havoc with this business because of the severely adverse conditions which prevailed in agriculture among the surplus producing nations In 1933 the total exports reached a value of only $12,215,308, but 8 per cent of

the 1929 figure! When the farmers of Canada, Argentina, and Australia are unable to sell their products advantageously, the machinery makers of the United States lose their markets and wage earners their jobs The interdependence of industry and agriculture, both nationally and internationally, is keenly demonstrated by the developments in this field during the past decade.

AMERICAN EXPORTS OF AGRICULTURAL MACHINERY

(Leading Countries in 1929 Source Commerce and Navigation of the United States)

	1929	1933
Canada	$37,714,000	$2,393,000
Argentina	35,342,000	1,181,000
Russia	20,121,000	109,000
Union of South Africa	5,681,000	831,000
Australia	4,734,000	543,000

THE ELECTRO-TECHNICAL INDUSTRY

World production of electrical energy derived either from falling water or from fuel, intended for use in the home as well as in industry and transportation, is increasing rapidly This increase is especially marked in those parts of the world which are both densely populated and highly industrialized, but even in many countries which do not fall within this category the consumption of electricity shows a consistently upward trend.

North America and Europe are the two continents which produce and consume the bulk of the world's electricity The total production of electrical energy in the United States reached 120,000,000,000 kilowatt hours in 1930, while European production probably slightly exceeded this figure. In some countries electrification is much further advanced than in others. In Switzerland, Norway, and some parts of the United States, for example, the use of electricity for all purposes is much more common than in Great Britain, Belgium, Germany or France, even though the latter are all countries with highly developed modern industries Even in the former countries, however, there is considerable latitude for a further increase in the consumption of electrical energy. In the United States

low-priced current will be furnished by a number of large scale hydro-electric plants which have either just been completed or are in various stages of execution, while, for example, such a large, industrially backward state as Russia is engaged in rapidly expanding its output of electrical energy.

Distribution.—In response to this growing use of electricity the electro-technical industry, which manufactures machinery and equipment ranging in size from the smallest appliances to the largest dynamos, has in little more than a quarter of a century come to occupy a strategic position in the modern economic structure. The principal seats of this industry are found in the countries which have large consumption of electrical energy and which at the same time possess highly specialized and well-established machinery industries. Other essential factors are, of course, capital resources and an adequate supply of skilled labor

In quantity and value of products the electro-technical industry of the United States ranks first by far and is followed at a considerable distance by the industries of Germany, the United Kingdom, and France Among the smaller producers must be mentioned especially Canada, Sweden. Italy, and the Netherlands. In recent years both Japan and Russia have made rapid progress in this field.

Electricity was first used on a large scale in the great city centers, and they have remained the principal markets for electrical goods These factors have favored the development of the electro-technical industries near large cities.

United States.—In the United States the principal manufacturing centers are located in Illinois, Pennsylvania, New Jersey, New York, Ohio, and Massachusetts.

The Chicago and Greater New York industrial areas lead all others in the production of electrical machinery, apparatus, and supplies. Centers of lesser importance are Philadelphia, Pittsburgh, Boston, and Schenectady. Elaborately equipped research laboratories—such as have been established at Schenectady, Pittsburgh, and Cleveland—have been highly effective in promoting the development of the electro-technical indus-

try. Their discoveries have led to the widespread use of new and improved appliances which have made possible higher standards of living for consumers and producers alike.

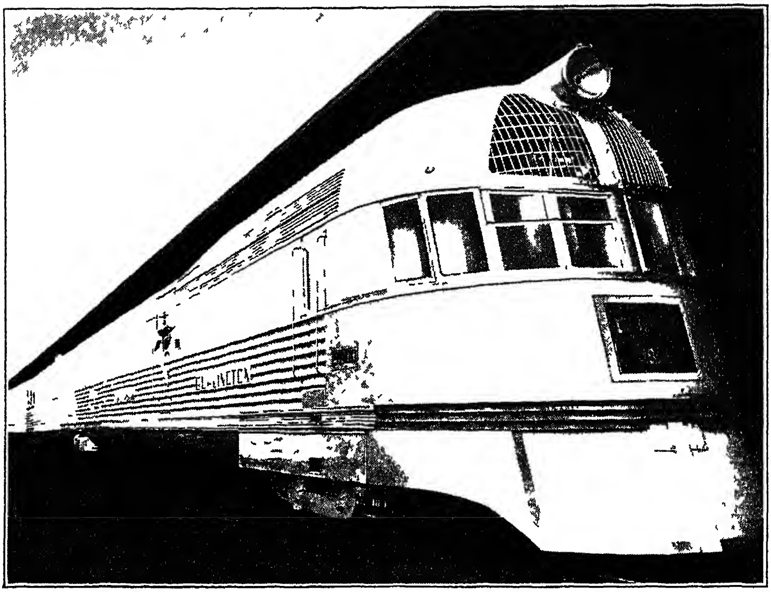
European countries.—The electro-technical industries are well developed in all the leading countries of Europe, notably in England, Germany, France, and Italy, the two first named being well in the lead Berlin, where this industry employs more than 60,000 persons, is the foremost center in Germany Over 80 per cent of all the German electric light bulbs are manufactured in the Berlin industrial area, which is also noted for its output of a large array of technical appliances Other important centers are located in the Ruhr-Rhine region, in Saxony, and in the cities of Stuttgart and Nürnberg.

England is particularly noted for its manufactures of cables and heavy electric apparatus Among the principal centers are the Birmingham, Manchester, and London industrial areas, where power, labor, and markets are all readily available

Exports of electro-technical products.—It is estimated that since 1913 the electro-technical industry of the world has more than doubled its annual output. As a result of the progress of electrification even in relatively remote parts of the world—such as Australia, New Zealand, and Argentina—the international trade in machinery and equipment needed for the production and consumption of electricity has greatly increased in importance. The principal producers also are the principal exporters—namely, the United States, Germany, and the United Kingdom. The exports of the United States are shipped largely to Canada and to Latin America, with the European market, however, not far behind. Germany finds its principal market on the continent, while most of the British exports go to other parts of the Empire. In recent years the Netherlands, Sweden, and Czechoslovakia have become important producers, primarily of such special products as electric lamps, radio articles, and vacuum cleaners. Because of the relatively small domestic demand of these countries, they have pushed vigorously ahead in the export markets.

THE TRANSPORTATION EQUIPMENT INDUSTRIES

Equipment with which to move people and goods may quite properly be classed as one of the fundamental material needs of man. On the basis of standards now in vogue, the stage of industrial civilization attained by any people is indicated by their mode of transportation. Those highest in the scale motor over land and sea or through the air; those lowest in the scale walk on land or paddle their way over sheltered waters in crude



Courtesy, Chicago, Burlington, and Quincy Railroad

Fig. 298.—The "Zephyr," a modern all-steel train equipped with Diesel engines. Designed for fast passenger traffic.

canoes. The industrially progressive countries have made great advances in railroad building, steamship construction, and in the manufacture of motor vehicles for use on land, water, and in the air. The industrially backward nations lack high development in these lines Quite naturally, however, the countries with bordering seas have generally made more progress in the building of sea craft than have inland countries.

In the United States the transportation equipment industries, taken collectively, constitute one of the leading manu-

facturing groups of the nation Even if railroad repair shops are not included, they rank fifth or sixth among the major groups of manufactures as to number of wage earners employed and according to value added by manufacture

Railway equipment.—In general, rails are made directly by the rolling mills connected with the larger steel plants and are included among the products of the iron and steel industry. This discussion, therefore, refers only to rolling stock equipment, such as engines, tenders, cars, coaches, and accessories

Although the railway repair shops are largely service institutions, the larger ones carry on true manufacturing operations and are necessary factors in the success of any railway system Repair shops, equipped and manned so as to be able to rebuild engines and rolling stock, must be a part of the railway transportation industry whether the country be as highly industrialized as Belgium or as slightly so as Paraguay. In the United States the railroad repair shops constitute a major industry, ranking about seventh or eighth among the groups in number of wage earners

The distribution of railroad mileage furnishes a key to the relative importance of the manufacture of railway equipment in the principal countries and continents In 1930 the railway lines of the world were estimated to reach a total length of about 770,000 miles, of which the United States alone had 32 per cent and Canada 5 4 per cent Europe was credited with 25 5 per cent, and Asia with 11 per cent, neither including Soviet Russia with its 6.3 per cent of the world's total unevenly divided between Europe and Asia

Railway equipment is manufactured by the countries which have both large steel industries and important home markets. Such countries are in the most favorable situation to supply equipment to less industrialized countries which have need for railway cars and locomotives. The United States, England, and Germany are examples of the former class, while Mexico, Argentina, and Australia illustrate the latter.

The motor vehicle industry.—The motor car may be said to be a European invention which was converted from the class of

luxury products to that of common necessities by American mass production through standardized machine methods Its extensive use has induced effects upon industry almost revolutionary in scope Little did those who viewed the French car designed by Panhard in 1894 dream that within the next three decades the motor industry would almost fill the highways with its products The world-wide significance of the motor car industry is reflected in the fact that at the close of 1930 it was estimated [1] that a total of over 36,000,000 motor cars were

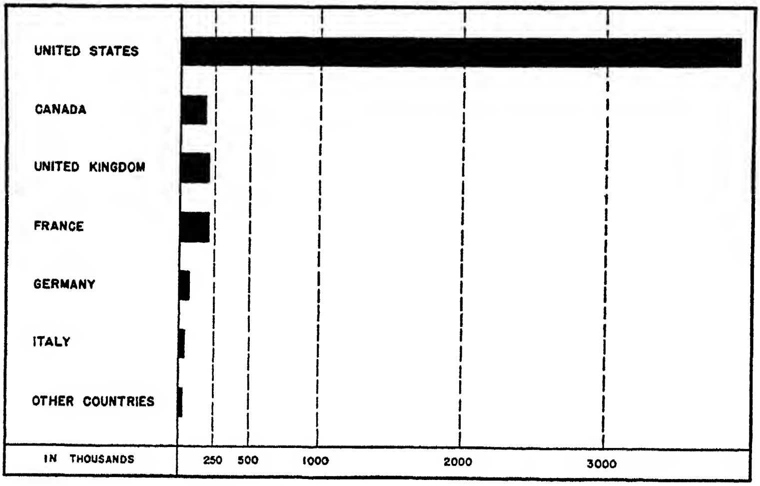


Fig. 299.—Production of motor cars by principal countries. Average 1925-1931. Output of assembling plants with countries of origin of material (Source. *Review of World Production, 1925-1931*, League of Nations, Geneva, 1932)

in use in the world. Furthermore, there were more than 2,800,000 motor cycles. Of the number of cars, the United States was credited with 74 per cent, the United Kingdom and France with about 4 3 per cent each, and Canada with 3.4 per cent. North America and Europe combined account for nearly 93 per cent of the world's motor cars and for practically the entire motor car industry—another illustration of the preponderance of these continents in the realm of manufacturing.

[1] *Statistical Year Book of the League of Nations,* 1931-33, p. 223.

The United States is, however, the only country wherein motor car manufacture is of such tremendous significance that the industrial prosperity of the nation is inseparably connected with it. It is estimated that the industry, under normal conditions (average 1926-1930), furnishes employment directly or indirectly to about 10 per cent of all persons gainfully employed The American people spend approximately one-tenth of their national income for the purchase and operation of motor cars, this item exceeding every other single class of merchandise except that of food and food products. The significance of motor car manufacturing to various other industries is indicated by the high percentage of their products it consumes: for example, 20 per cent of the steel, 54 per cent of the malleable iron, 80 per cent of the rubber, 43 per cent of the plate glass, 23 per cent of the aluminum, 34 per cent of the lead, and so on. Every state in the Union and many foreign countries supply materials for this industry. A prominent manufacturer has stated that his company alone uses in a year the total output of cotton produced on 433,000 acres, the wool from 800,000 sheep, the leather made from the hides of 30 000 cattle, the hair from 875,000 goats, 500,000 bushels of corn, and the beeswax produced by 93,000,000 honey bees Surely the economic importance of the motor car industry to farms, mines, factories, and labor can hardly be overstated

Centers of automobile manufacturing in the United States.—The earliest automobiles were popularly known as horseless carriages Prior to the motor car age the most successful centers for the manufacture of wagons and buggies had developed in the eastern part of the great grain growing belt, where raw materials, power resources, labor, and markets were all at hand. Michigan, Wisconsin, Indiana, and Ohio were noted for their prosperous wagon and carriage factories These had developed where the manufacturers were able to obtain at comparatively low cost the woods best adapted for the different parts of the vehicles, such as soft woods from the Lake Superior region and various species of broadleaved hardwoods from the adjacent forests The expanding agriculture of the

plains, with its rapid growth of farm and village population, provided splendid market outlets. Successful wagon and carriage concerns were the logical results.

When motors, particularly the internal combustion engine, were applied to locomotion it was natural that they should first be mounted on carriages, and it was equally natural that carriage makers and motor makers should combine their plants. Thus a number of the well known carriage makers turned early to automobile manufacture; among some of the best known examples may be named, Haynes, Mitchell, Olds, and Studebaker. Some who had been successful as carriage makers for one reason or another failed to make the shift successfully, and their names have disappeared from the lists of today. Reorganizations have caused some companies to take on new names, but if one traces their history back to the beginnings he will find there a wagon factory. Still others carry proudly the original names on the flag poles of their factories today. The centers of manufacture remain, however, in the states which were leaders in the carriage industry.

The manufacture of motor cars thus has become distinctly localized. Accepting 1929 as a basis for interpreting the distribution of car and accessories factories, we find 48 per cent of all the wage earners were employed in Michigan, Ohio was a poor second with 12.7 per cent, followed in turn by Indiana with 9.1 per cent, New York with 4.17 per cent, and Wisconsin with 4.15 per cent. The 20 per cent of wage earners not accounted for in the above states were employed to a large extent in scattered accessories factories, with a few in motor car making in other states.

Trends of trade.—The motor car industry is essentially a development of the present century. The census reported only 4,192 cars and trucks made in the fiscal year ending June 30, 1900. At first, growth was slow, the annual output did not reach the 100,000 mark until 1909, and the 1,000,000 mark was first exceeded in 1916. Since 1922, in every year except 1932, the 2,000,000 figure has been exceeded, and in 1929 the remarkable total of 5,358,420 motor vehicles was reached. It

seems clear that, while the period of rapid expansion is over, the motor car industry will retain a position of high importance in the economic life of the nation.

Foreign trade.—The drop in exports of American motors since 1929 has been even greater than in many other lines. Inasmuch as other exporting nations report similarly pronounced decreases, the people of importing countries apparently still consider motor cars as luxuries. It is well known that in periods of economic adversity trade in luxury articles suffers more than trade in articles essential for carrying on the customary activities of life. In 1929 the total value of motor cars and accessories exported was $539,298,000; in 1933, it was but $90,630,000 In 1934 the value of exports was $190 208,-000, showing a marked advance over the low point of the previous year.

U S A EXPORTS OF MOTOR CARS AND ACCESSORIES TO PRINCIPAL FOREIGN MARKETS

(Source of Data Commerce and Navigation of the United States)

Country	1929	1933
Canada	$102,762,000	$14,628,000
Argentina	53,711,000	4,451,000
Australia	36,711,000	2 612,000
Brazil	27,969,000	3,825,000
Belgium	26,468,000	7,189,000
United Kingdom	25,181,000	2,225,000
Germany	19,483,000	804,000
Union of South Africa	19,214,000	5,903,000
Japan	19,016,000	5,454,000
Spain	16,652,000	3,057,000

The high quality of low priced American motor cars will continue to promote exports unless the surge of economic nationalism which seems so general now should lead to the levying of still higher import duties against them, or unless embargoes or reduced import quotas should become established. Viewed broadly, such policies do not promote international prosperity or goodwill; their effects lead to reduced standards of living The trends of development in recent years make them an unwelcome reality which must be taken into account as one views future possibilities

The aircraft industries.—The aircraft manufactures consist of two main products—namely, (1) the lighter-than-air and (2) the heavier-than-air crafts. The *dirigible* is the newest development of the former and is the only type that seems to offer possibilities for commercial development; *airplanes* of various kinds typify the latter. On the basis of present status and outlook for the near future, the heavier-than-air craft is the only class that can be taken up in this brief treatise

The first successful venture in a powered plane is generally credited to Wilbur and Orville Wright, who made a flight of 12 seconds at Kitty Hawk, North Carolina, on December 17, 1903. Developments were slow until the World War, when military demands spurred improvements with frantic haste. Commercial transportation followed, and during the past fifteen years air lines have been extended to nearly all points of the world. Even the poles have been visited by the pioneers of the air In the United States the solo flight of Charles Lindbergh in 1927 gave enthusiastic impetus to the expansion of air traffic

The airplane industry is a young field of activity and one of world-wide significance Every nation has an interest in it, and all the industrial nations are engaged in the manufacture of its craft. On account of its direct military significance, detailed data are carefully guarded; but the tremendous progress made by all the great powers in recent years, both in number of aircraft and in their efficiency, is generally conceded

In the United States the number of establishments engaged in the manufacture of aircraft and parts increased from 31 in 1919 to 132 in 1929; the number of wage earners employed increased from 3,543 to 14,710, and the value added by manufacture increased from $7,246,000 to $43,785,000 The first effects of the depression brought severe curtailment of the industry, but the rate of recovery to date has been far above that of industry in general.

Airplane manufacturing is not so highly localized as is the automobile industry New York holds first place in number of men employed, followed by Michigan and California Since

the value of the product is largely dependent upon accuracy of design and skill in execution, the industry is less closely related to natural resources than are most of the great manufacturing establishments. The factors which have been most important in the development of manufacturing centers are largely non-geographic; skill, local pride, inventive genius, and daring on the part of men and capital have superseded in importance the availability of raw materials, power, and markets. The result is a widely scattered industry It is probable that as the industry matures, a greater degree of concentration will develop, probably near the motor-engine factory centers.

Export trade.—American export trade in aircraft and accessories is an important phase of the industry. Latin America is ordinarily the foremost market, a situation readily accounted for by its nearness and resulting capital interests Inasmuch as aircraft service is highly practical as a means of transport and communication for the countries beyond the Rio Grande, because of their vast areas not serviced by railroads or motor highways, we may expect this trade to become of increasing importance in the years ahead.

The boat and shipbuilding industries.—Boats were perhaps the earliest vehicular means of transportation built by man, and water transportation remains one of the foremost means of haulage, and also usually the most economical. However, until quite recently boats were small and slow moving; even steamships were of comparatively small size until the latter part of the nineteenth century. During the past four decades great strides forward have been made in size, speed, and efficiency.

The tonnage of the merchant marine fleet of the world furnishes a fairly accurate index of the shipbuilding industry. The following table presents the situation as of 1931, since which time there have been no significant changes. It is apparent that the United Kingdom holds premier position by a wide margin and that, in proportion to area and population, the Norwegians and the Dutch are leaders as seafaring people The importance of the shipbuilding industries, in general, is

MERCHANT MARINE OF THE WORLD AND OF PRINCIPAL COUNTRIES

(Gross tonnage)

(Source Statistical Year Book of League of Nations, 1931-32)

United Kingdom	20 303,000	Norway	4,066,000
United States	13,541,000	France	3,566,000
Japan	4,276,000	Italy	3,336,000
Germany	4,255,000	Netherlands	3,118,000
World			70,131,000

proportionate to that of the role which various nations play in ocean shipping.

Shipbuilding in the United States.—Water transportation in this country involves lakes, rivers, coastal waters, and the open ocean. The Great Lakes are of such importance in this regard that they account for over 2,400,000 gross tons of the merchant marine. Ships also ply the larger rivers, and others serve the ports of all our coasts. An important boat and shipbuilding industry has developed to provide vessels and service docks for these transportation lines.

Since shipyards for building seagoing vessels must be located adjacent to deep water, they are generally constructed at or near large shipping ports. Other geographic factors of importance are availability of labor and of the materials necessary for construction, especially steel. In the United States the largest centers are at Quincy, Massachusetts, Kearney and Camden, New Jersey, Chester, Pennsylvania, and Newport News, Virginia. Important shipyards are also located on the Pacific Coast as well as along the Gulf and south Atlantic Coasts.

Trends and outlook.—Shipbuilding is looked upon by all the larger countries as an industry intimately linked with national defense as well as one that is essential to economic welfare in times of peace. Therefore, building operations are often aided by various grants and subsidies in one form or other at the expense of the public Later, when the ships are in service they are favored by mail contracts which pay exorbitantly for the actual service rendered, or direct subsidies are granted. Under such conditions the nations inevitably be-

come competitive to maintain merchant fleets largely at public expense and without consideration for actual needs Hence, the future appears to assure, in general, continued activity at remunerative returns for those engaged in shipbuilding When and if war fever sways the nations, the activity in shipbuilding tends to rise materially. Such emotional responses may not be economically sound, but they are a form of reality, perhaps unhappily so

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CHAPTER XXXI

The Changing World

WHY do such conspicuous areas of density and of sparseness exist as are shown on maps of world population? In the first two chapters of this book we not only raised questions as to the causes of this uneven distribution, but also as to the consequences, particularly those of economic significance. Through the chapters which followed we have attempted to hold rather closely to the four queries suggested at the outset—namely, (a) where, (b) what, (c) why, and (d) what of it? While we cannot now attempt to summarize all that has been presented in the foregoing chapters, it may be well for us to recall some of the most salient phases of the causes and consequences attending the distribution of the two billion or more people who possess this earth Broadly speaking, the distribution of population is directly related to environmental factors, although in the details of distribution non-geographic factors often play important roles.

Uneven distribution of natural resources.—Fundamentally, population must adjust itself to the means available for making a living In the pre-industrial ages agricultural land was the principal natural resource which governed density of population Even now the most densely populated large areas are found where man depends almost entirely upon local agricultural production This is notably the case in India and China, where 75 to 80 per cent of the people live on farms Fertile cultivable lands with a favorable climate must still be ranked as the world's great population breeders. Now, as in ages past, such lands not only produce the materials necessary for human existence, but also give rise to surplus population. The lands capable of such productivity are limited and uneven-

ly distributed over the earth. Other lands have lower potentialities and hence cannot support large numbers Cultivable lands are the rich grain lands, and there people may become numerous; non-cultivable lands at best are but pasture lands and are thus foreordained to sparseness

With the development of mechanized industry, however, the basic resources used by man have been extended beyond those of the agricultural lands to the realms of minerals and power. Moreover, industrial development has made it possible for men equipped with machines to produce large surpluses of agricultural goods and thus to release workers for mines and factories. In the United States, for example, according to the census of 1930, only 24.5 per cent of the total population were classified as rural, and it is highly probable that 10 to 15 per cent could supply the entire needs of the nation for agricultural products The high development of industry in western Europe would not have been possible without the surplus produced by machine agriculture in the United States, Canada, Argentina, and Australia

Industrialization, particularly in eastern North America and northwestern Europe, has given rise to areas of congested population where the production of factory goods constitutes the principal economic activity. This activity utilizes mineral and power resources rather than agricultural lands, although the demand for food induced by the dense industrial population leads to intensive production of agricultural commodities as well, particularly of such vegetables and dairy products as cannot readily be shipped long distances. Thus, natural wealth of minerals, power fuels, and waterpower tends to induce areas of heavy industrial population. These natural resources, like the productive agricultural lands, are also distributed very unevenly over the earth.

Uneven distribution and diversity of production.—Productivity is dependent, however, upon the human resources as well as upon those of the plant and mineral worlds. Man is as necessary an element as is soil or coal and iron ore. Primitive man depends directly upon the resources of his immediate en-

vironment. He is enabled to live in a given locality if wild life—plant and animal—is found in sufficient quantity for his subsistence The skills needed are those of selecting nourishing plant products, avoiding the poisonous ones, and of capturing game and fish. The problems of living are simple and the diet is monotonous This is an example of local self-sufficiency. In that state of society man has not acquired the mechanical skill necessary to harness sources of energy outside of himself, and he has not learned how to coöperate in the exchange of surpluses with others who live at remote distances.

As man advances in the scale of civilization he increases the efficiency of his methods of production of goods to satisfy his material needs No longer is all his time devoted to the hunt and chase or to crude tilling of the soil for the sake of meeting his elemental needs of food, clothing, and shelter He learns how to harness other sources of energy and to use other forms of power than his own Such development has been in progress during all the ages past. Animals were trained to carry burdens and to pull loads; winds and streams were early utilized by means of crude windmills and waterwheels; and later the energy of coal, petroleum, and natural gas was made available as power through the mediums of gas and steam engines and electric motors. These can now be utilized efficiently to do work on a grander scale and at a much lower cost than would be possible if only the labor of men and animals were available. In the industrially progressive nations man is engaged mostly in directing the energy whereby the work of production is accomplished, and his own muscular power plays but a minor role. Because of the enormous amount of energy he now has at his command, his capacity to produce goods and to transport them has surpassed the most optimistic dreams of a century ago

However, even modern man and his machines are limited in their activities by the environment in which they operate That they can "conquer nature" to a degree beyond that possible in the pre-machine eras is quite true, but the economic limits are quite closely drawn. Man *can* produce bananas in

the middle latitudes, but only at enormous cost compared with their production in the tropics Excellent table grapes are produced in England, but the cost is many times as great as in the Mediterranean lands, where they are grown under favorable climatic conditions. Man could build as good railway locomotives in Arizona as in Pennsylvania, but the cost would be much higher because of the necessity of transporting the raw materials from distant sources Therefore, it is clear that, even with the great technological advance which marks the modern industrial world, economic production depends upon the fundamental factors of soil, climate, power resources raw materials, and available markets. These factors have different relative weights in the various sections of the world, but none can be ignored if efficient production is to be attained.

Under modern conditions the production of many agricultural and industrial commodities tends to be highly localized. Certain areas may have optimum natural conditions for the output of only a few products, while other commodities can be produced more efficiently elsewhere If men desire to have the benefit of many commodities, they must arrange to exchange their local surpluses for goods produced elsewhere The local self-sufficiency of pre-industrial days is not now possible within sound economic limits; high standards of living are inseparably linked with exchange of products. The physical facilities for such exchange have been developed in remarkable degree Steamships span the seven seas and connect the continents speedily and efficiently; railroads and improved highways facilitate swift overland transport; canals and rivers carry bulky and slow-moving cargoes at low cost; air navigation can now reach nearly any part of the earth at amazing speed and with little hazard Communication by mail, wire, cable, and radio binds the world together so closely that the most distant points can hold converse upon a few minutes notice. As far as production, exchange of goods, and communications are concerned, the stage is set for progress at a rate which staggers the imagination. In the face of all this we seem to be in a nearly stagnant situation. Why? The oft-repeated

answers of over-production, too much mechanization, economic maladjustment, and so on, are unconvincing The solution of the problems of continued progress and improved standards of living for the masses demands the attention of all thinking people everywhere.

Primitive peoples must depend upon local self-sufficiency because they have not harnessed power, have not established rapid and efficient means of transportation, and have not developed a widespread system to facilitate exchange of either goods or services. Advanced industrial society, having accomplished all these ends to a remarkable degree, should not be tempted to return to the primitive standards even though some of the economic problems of modern society have not been solved. Production, both in kind and quantity, necessarily varies with geographic conditions High standards of living, however, depend not only upon production, but also upon a ready exchange of products, that is, upon trade

Trade as an index of civilization.—We believe it fair to assert that the term *civilization* implies recognition of the rights of other people or persons as well as insistence upon one's own rights; that it implies a state of mind as well as a state of material and cultural achievement Neither an individual nor a nation deserves to be called civilized if it wilfully ignores or overrides the rights of others and is unwilling to trust controversial issues to the verdict of neutral, fair-minded judges. Such breaches of conduct are nearly always causes of war or are associated with it, and readiness to resort to war surely cannot be considered an index of civilization Disregard for the rights of others is not, however, limited to war conditions; too often it occurs in times of peace as well, and most blatantly so in the realms of trade

Since it cannot be denied that trade tends to promote high standards of living, is it not fair to hold that honest promotion of trade is a sacred duty and should be regarded as such? Is not the trade obstructionist an enemy of progress? Because of the distribution of natural resources, the various regions of the earth can each produce some commodities advantageously,

others with difficulty, and still others not at all Pennsylvania and West Virginia, for example, can produce cereals and meats, but not so efficiently as can Iowa and Kansas, whereas they can produce heavy manufactures of iron and steel more efficiently Will anyone deny that a ready flow of trade between the former and the latter named states is sound business practice? Similarly, the exchange of the fruits of Florida and California for the manufactured goods of New England and the cereals of the Mississippi Valley meets general approval. One wonders, however, what might have been the result if the territory which is now the United States had been occupied by a number of small countries, as is the case in Europe. That the builders of the Constitution recognized the significance of this problem is clearly shown by their action in preserving for the national government alone the right to levy import duties. In this manner economic restrictions upon the ready flow of interstate trade were effectively prevented.

The United States, because of its vast size and widely varied resources, is about as nearly self-sufficient as any nation on earth Nevertheless, the highest welfare of our citizens demands the encouragement of foreign trade. Some commodities, such as coffee, tin, and rubber, must be purchased abroad because we cannot produce them from our own resources, while others, as tea and sugar, can be produced elsewhere at so much lower cost that to attempt to supply our entire needs would be highly uneconomic in practice. Furthermore, our capacity of production in some lines, both agricultural and industrial, is so great that exports are absolutely vital if labor is to be employed on a full-time basis Thus, for our domestic prosperity, a ready flow of imports as well as of exports is a necessity

Economic nationalism in relation to economic progress.—Since the World War economic nationalism has developed with increasing vigor. The war was responsible for disrupting the economic machinery which had begun to function quite smoothly during the preceding period of peace The nations at peace as well as those at war were obliged to forego the use of many imported materials which they had come to rely upon; hence a

psychology of fear was established which led to a widespread ambition for each country to produce all commodities possible without regard to economic feasibility Within the United States the industrial expansion induced by the war demands had caused a factory development far in excess of domestic needs Through increased tariffs, industrialists hoped to protect the home markets against foreign competition, and yet not to relinquish their favorable position in the world markets. European countries, ordinarily our greatest foreign customers, not only found themselves impoverished by the destruction wrought in 1914-1918, but also found their markets in the United States curtailed by tariff walls of rapidly mounting height. Furthermore, their pre-war trade with other nations had been seriously impaired and in many instances totally destroyed.

Post-war business was confronted by a hostile, suspicious world Foreign trade was hampered not only by national suspicions, but also by lack of financial resources and lack of credit. Under the circumstances, nations began to rebuild on a basis of self-sufficiency Italy, for example, entered upon a campaign to produce her own wheat rather than to buy it, even though she could obtain it more cheaply from Argentina and the United States Germany took up the cry of self-sufficiency in breadstuffs and fats, although it is not a country well adapted for wheat raising, and normally should import great quantities of lard and other animal products Similar movements were widespread among the nations of the world, and in too large a measure they still persist.

For a time the effects of these policies were not keenly felt because a decade was necessary in which to refill the gaps left by the wholesale destruction wrought during the World War. The United States particularly experienced a post-war prosperity for which a heavy price was paid, although it was not so understood at the time The nation had a tremendous surplus productive capacity in agriculture and industry, and it had accumulated huge wealth for which channels of investment were sought Foreign markets were beckoning. The surplus production was sold abroad and paid for by loans of American

money. Exports increased to huge proportions under such stimulus, and, while imports also increased, Americans boasted of their large "favorable trade balances" reported yearly The United States, which had become the world's greatest creditor nation through loans granted during the War, held with almost childish simplicity to the belief that foreign countries could pay their debts by continued borrowing of money and by buying more of us than they were selling to us.

That belief was, of course, one impossible of realization. After a time it dawned upon business that the profits of which it had boasted were being paid for by capital rather than by income from earnings. Foreign purchasers found it necessary to borrow still more money for the payment of interest on moneys already owed, and hence the balances available for new purchases became smaller. The speculative structure, domestic and foreign, which had been built upon the false basis above outlined, tottered, and, after a few warning tremors, crumbled in the great crash of 1929 It was a cruel but inevitable ending of an economic pipe dream.

Since that time the struggle for national economic self-sufficiency among the countries of the world has continued with fury unabating. As trade has declined, each nation has tried to remedy the difficulty by making trade even more difficult. When duties alone seemed insufficient to reduce import trade, quotas were established, and in some cases absolute embargoes. With almost universal agreement that economic difficulties arise when distribution is impaired, the remedy sought by national leaders has been *further impairment!* Can there be any doubt that economic nationalism is a hindrance to economic progress?

Business—a form of public trust.—In our modern industrial civilization the type of courageous integrity represented by the pioneer woodsman or plainsman of the advancing frontier must be replaced by similar courage and integrity in a setting much more difficult. Coöperation is necessary for the achievement of success in a complexly organized society. The pioneers along the new social and economic frontier must

not only be men of undaunted courage, they must have the scientific spirit; they must ever search for truth and take their stand in line with facts insofar as it is possible to ascertain the facts. While recognizing the truth of the adage, "Production is the basis of wealth," they must recognize that general and continued prosperity depends upon fair and widespread distribution of the benefits of production Maladjustment of the machinery of distribution is as certain to produce want and suffering among innocent victims as is maladjustment of the machinery of production.

Whatever criticism may be made of the industrial progress attained, it cannot be denied that our ability to produce has been so enhanced that the fear of famine has been dispelled. Among modern nations the economy of scarcity has no place Agricultural and industrial goods can be produced in such quantities and with such efficiency that all may have comparative abundance No longer need there be fear of a world growing old, nor need there be fear of imminent overpopulation A change of major importance has come in the shift from rural to urban population. The farmer population, formerly three-fourths of the total, always retained its land, which carried with it a feeling of social security Now we have a great industrial population, largely without direct property interests, and one whose whole future is tied up in terms of jobs Under such conditions social and economic security, vital to the people as individuals and to the life of the nation as well, must rest upon a firm foundation of justice to both labor and capital. The worker deserves full consideration as a human being, as a partner in the business game, and not merely as a cog in the machine. The efficiency of production is such that men need to work fewer hours than in the past and yet have all that they are prepared to enjoy. Such an industrial status is indeed a tribute to the efficiency of mechanical inventions in the utilization of available power resources.

What of the future? Is it not true that we are living in a world of rapid change? The productive genius of man has been ably demonstrated and the necessity of the scientific spirit is

clearly evident. The social genius is still to be tested. Man must study the world in which he lives He must familiarize himself with his own environment and also with the environment in which others live He must search for the facts as to the qualities, kinds, and distribution of the natural resources upon which production depends He must learn to use wisely, with true ideals of conservation, the resources which are irreplaceable. A scientific study of the best use of the land will help to avoid economic waste and its associated hardships. But even more is needed He must have courage to voice his convictions and to plan his actions in accord with facts. Intellectual honesty often requires the highest type of courage.

In the social and economic world which confronts us are problems which should fire adventurous minds with enthusiasm. There is need for the brightest and most daring minds to work unceasingly at the tasks of learning fuller truths about the material world in which we live That, however, cannot be the final goal. Beyond lies the problem of developing greater and deeper human happiness as a reward for the increased productive efficiency. Men will have many hours daily wherein they need not toil at grinding tasks Such hours will be theirs for the development of their higher needs. Those hours should be conducive to scholarship, to literary achievement, and to the fine arts of painting, drama, and music May those hours become, in a true sense, ennobled leisure!

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